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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Full Page Advt., page 91, May 28.

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See Full Page Advertisement, May 28.

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See half-page Advertisement page 53, June 11.

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TENDERS.

TO ENGINEERS AND OTHERS.

The Metropolitan Asylums Board invite

Tenders for Installation of

New Steam Boiler, Ironing Machine, Pipework and Engineering Work for Laundry, at Princess Mary's Hospital, Cliftonville, Margate, Kent, in accordance with drawing and specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The drawing, specification, and form of tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after 10 a.m. on Monday, 14th June, and the drawing, specification and form of tender can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a bona fide tender sent in accordance with the instructions on the form of tender, and after the specification and the drawing have been returned.

Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 7th July, 1920.

(By Order)
DUNCOMBE MANN,
Clerk to the Board.
H 191

CORPORATION OF GLASGOW.

TRAMWAYS DEPARTMENT.

TURBO-ALTERNATOR for PINKSTON GENERATING STATION.

The Corporation of Glasgow are prepared to receive

Tenders for the Supply and

ERECTION of the following:—
ONE 10,000 K.w. STEAM TURBO-ALTERNATOR with CONDENSING PLANT.

Specifications, with conditions and Forms of Tender, can be had on application to MR. JAMES DALRYMPLE, General Manager, 46, Bath Street, Glasgow. Sealed Tenders, marked outside "Tramways—Tender for Steam Turbo-Alternator Set," must be lodged with the subscriber not later than Ten a.m. on TUESDAY, 6th July, 1920.

The lowest or any offer may not be accepted.

J. LINDSAY,
Town Clerk.

City Chambers,
Glasgow.
10th June, 1920. H 216

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.

(PLANT AND MACHINERY SECTION).

TIP WAGONS.

For Sale by Public Tender.

43 Steel, DOUBLE-SIDE TIP WAGONS, 1 yd. flush capacity, 60 c.m. gauge, capable of being slung and tipped while slung, fitted with brakes and spring draw-gear, roller bearings, etc. Lying at C.S. DEPOT 125, Military Wharf, Purfleet, Essex.
41 Steel, 1 yd. SIDE TIP WAGONS, 2ft. gauge.
16 " ½ yd. " " " " "
Lying at Richborough.

Permits to view and Tender Forms may be obtained on application to the CONTROLLER, D.B.I.s., Plant and Machinery Section, Charing Cross Huts, Embankment, W.C. 2.

Tenders to be returned not later TEN a.m., JUNE 25th, 1920.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d. at all Bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 976

HOLBEACH PARISH CHURCH.

The HEATING COMMITTEE are prepared to receive

Tenders for Heating the

above CHURCH on the low pressure system.

To supply boiler, pipes, radiators, labour, &c., necessary to heat Church, 177 ft. long, 70 ft. wide with Chancel, Nave, 2 side Aisles, and Tower.

Stokehole and Flue will be separate contract, executed locally.

Further particulars may be had from, and Tenders sent to—Revd. Canon HUTCHINSON, The Vicarage, Holbeach—on or before Sat., 10th July, 1920, marked "Tender for Heating."

The Committee do not bind themselves to accept the lowest or any Tender. H 237

METROPOLITAN WATER BOARD.

Tenders for the Supply and Erection of One Triple Expansion PUMPING ENGINE at West Wickham Well, Kent.

The Metropolitan Water Board invite

Tenders for the Supply and

ERECTION of ONE TRIPLE EXPANSION PUMPING ENGINE at their Well, West Wickham, Kent.

Forms of Tender, Conditions of Contract, Specification and Drawings, may be inspected without payment of fee at the Offices of the Board, Room 182, Chief Engineer's Department, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Monday, 21st June, 1920. Contractors desirous of tendering may obtain the necessary documents from MR. HENRY E. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £5, which sum must be deposited with the Board's Accountant and will be returned on receipt of a *bona fide* tender together with incidental papers.

Such payments and applications must be made between the hours of Ten a.m. and Four p.m. (Saturdays Ten a.m. and Twelve noon). Tenders enclosed in sealed envelopes addressed to The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1, and endorsed Tender for Pumping Machinery, West Wickham, must be delivered at the Offices of the Board not later than Ten a.m. on Thursday, 26th August, 1920.

A. B. PILLING,
Clerk of the Board.

Offices of the Board,
173, Rosebery Avenue, E.C. 1.
9th June, 1920. H 249

SALE BY TENDER.

To Engineering Concerns desirous of acquiring a New Works with fully equipped New Plant in Manchester.

Re MESSRS. NEWTON-HARPER, under Dissolution of Partnership.

MOTOR CAR ENGINEERING WORKS known as VICTORY WORKS, STRETFORD, MANCHESTER.

To be Sold by Tender, the

above-mentioned recently erected and well-equipped MOTOR CAR ENGINEERING WORKS, with the business and Goodwill thereof, as a going concern, situate at and called "Victory Works," in Stretford, Manchester, and now carried on by the firm of Messrs. Newton-Harper, who are dissolving partnership.

The Works were erected in 1919 and are situate within 3½ miles of the centre of the City of Manchester, on the Chester Road Main Car Route and within a short distance of Stretford and Old Trafford Railway Stations.

The Site contains an area of 14,489 square yards, including street land, and is held on a Lease for 999 years from the Trustees of the Trafford Estate at a yearly rental of £162 7s. 6d. and subject to the usual covenants contained in Leases of the Trafford Estate.

The Buildings are extensive and planned on the most modern lines. All the Machinery and Plant is of the most modern description, while the Electrical power and Lighting installations are of the latest and most approved type.

The Stock in Trade of raw material and finished and unfinished goods will be taken over at a valuation by the purchaser.

In addition the whole of the Patent Rights appertaining to the 12 HP. Newton Chassis (excluding the Italian Rights), and the Drawings and Specifications in connection therewith will be sold with the business.

The above is offered for sale in two separate lots, namely:—

LOT 1, which comprises the Motor Car Engineering Works and the site thereof as aforesaid and all the machinery and fixed and Loose Plant used in connection therewith and the Stock in Trade, the Patent rights of the Newton Chassis, and the Goodwill of the business (except the Goodwill and Stock in Trade attached to Lot 2) as a going concern with the benefit of all pending contracts.

LOT 2. The Goodwill in connection with the specialised manufacture of Broaches for Engineering Works which is now carried on by the firm as a separate Branch of the business and the whole of the Drawings and the benefit of all pending contracts in connection therewith and all the Stock of special steel used in this Department. No Tools or Machinery are included in this Lot.

The name Newton-Harper is excluded from the sale and the Purchaser shall have no right to use such name nor either of such names. Detailed Particulars of the Property and Inventories of the Machinery, Plant, &c., to be sold together with Conditions of Sale and Form of Tender attached, have been printed and may be had on application to any of the undersigned.

Tenders on the Form supplied must be sent in on or before the 1st July, 1920, addressed to FRANK DOWLER, Esq., Chartered Accountant, 6, King Street, Manchester.

All further information that may be desired and orders to view may be obtained from the above named.

FRANK DOWLER, Esq., the Receiver appointed by the Partners.

F. S. AIREY, ENTWISTLE & CO., Auctioneers and Valuers, 10, Norfolk Street, Manchester, or

F. O. S. LEAK & PRATT, Solicitors, 4, John Dalton Street, Manchester. H 120

AUCKLAND HARBOUR BOARD. NEW ZEALAND.

Tenders are Invited for the

SUPPLY of ONE Two Ton TRUCK CRANE. Specifications can be obtained on payment of a deposit of Two Guineas, at the office of the Board's Agents, Messrs. W. & A. MCARTHUR, LTD., 18/19, Silk Street, Cripplegate, London, E.C. 2.

Tenders to reach Messrs. W. & A. MCARTHUR, LTD., not later than 31st July, 1920. G 775

APPOINTMENTS OPEN.

UNIVERSITY COLLEGE, NOTTINGHAM.

MINING DEPARTMENT.

Applications are Invited for

the POSITION OF LECTURER in Colliery Engineering, whose duties will involve lecturing to Mining Students on Mechanics, steam, compressed air and general power distribution. Preference will be given to candidates who have had practical experience in the manufacture and installation of colliery plant. Salary £400.

Further particulars and forms of application, which must be returned by June 30th, may be obtained from the REGISTRAR. H 79

UNIVERSITY COLLEGE, NOTTINGHAM.

MINING DEPARTMENT.

Applications are Invited for

the POSITION OF LECTURER in Fuels and Oils, who will also be required to undertake lectures in general elementary chemistry, mine gases, explosions, gob fires, and coal carbonisation, to Mining Students. Salary £400.

Further particulars and forms of application, which must be returned by June 30th, may be obtained from the REGISTRAR. H 80

WOLVERHAMPTON EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL SCHOOL.

Wanted, in September next,

a FULL-TIME LECTURER in MECHANICAL ENGINEERING. University degree, or its equivalent, and teaching experience essential. Salary £300, rising by annual increments of £25 to a maximum of £400. Application form and further particulars can be obtained upon sending stamped addressed foolscap envelope to the undersigned. Applications must be received by not later than 30th June, 1920. Canvassing prohibited.

T. A. WARREN,
Director of Education.

Education Offices,
Town Hall,
Wolverhampton.
7th June, 1920. H 56

CITY OF BIRMINGHAM EDUCATION COMMITTEE.

Required in September next,

the full time SERVICES of LECTURERS in the following subjects:—

MUNICIPAL TECHNICAL SCHOOL
(Principal—W. E. SUMPNER, D.Sc.).
Physics, Electrical Engineering, Mechanical Engineering.

HANDSWORTH TECHNICAL SCHOOL
(Principal—W. E. HARRISON, A.R.C.Sc.),
Mechanical Engineering.

The commencing salary offered will depend upon the previous training and experience of the candidates.

For full particulars apply to SECRETARY, Municipal Technical School, Suffolk Street, Birmingham, specifying post in respect of which particulars are required. H 118

DUDLEY EDUCATION COMMITTEE.

DUDLEY TECHNICAL SCHOOLS.
Principal - J. H. GRIMDLEY, D.Sc., M.I.Mech.E.

The Dudley Education Committee

Require the Services of Two

ASSISTANT LECTURERS in Engineering. Candidates must possess good, practical experience, and either a University degree or academic qualifications of approved standard in mechanical engineering.

Commencing salary £300 to £350, according to qualifications and teaching experience.

Full particulars may be obtained from the undersigned, to whom applications should be forwarded not later than June 25th.

J. WHALEY,
Director of Education.

St. James' Road,
Dudley. G 980

CITY AND COUNTY BOROUGH OF BELFAST.

The Technical Instruction Committee invite

Applications for the Follow-

ing POSITIONS in the MUNICIPAL TECHNICAL INSTITUTE, Belfast:—

LECTURER and DEMONSTRATOR in MECHANICAL ENGINEERING. Remuneration £350 per annum, including Bonus, rising to £420 per annum. (It is essential that Applicants for this Position should have a University Degree in Science or Engineering).

ASSISTANT LECTURER and DEMONSTRATOR in MECHANICAL ENGINEERING. Remuneration £320 per annum, including Bonus, rising to £370 per annum.

Two ASSISTANT LECTURERS and DEMONSTRATORS in PHYSICS and ELECTRICAL ENGINEERING. Remuneration, for each Assistant, £320 per annum, including Bonus, rising to £370 per annum.

Particulars of the Duties and Conditions of Appointment may be obtained from the undersigned, with whom applications on the Special Form provided for the purpose, must be lodged not later than Noon on TUESDAY, 29th JUNE, 1920.

Applications should be accompanied by copies of three recent testimonials (original testimonials must not be sent).

Canvassing is strictly forbidden and will disqualify.

RUPERT STANLEY, Principal,
Municipal Technical Institute,
Belfast. H 213

THE UNIVERSITY COLLEGE OF SOUTHAMPTON.

LECTURER IN MECHANICAL ENGINEERING.

Applications are Invited for

the above POST, at a salary of £350 per annum.

Applications to be sent in by July 5th to the REGISTRAR from whom particulars may be obtained. H 150

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal - CHARLES COLES, B.Sc. (Lond.).

The Services are Required of

an ASSISTANT LECTURER in the Engineering Department, whose duties will be concerned mainly with Laboratory work.

Commencing salary £350 per annum, rising by annual increments of £20 to £450 per annum.

Applicants should have had workshop training, teaching experience, and good experience in the Engineering Laboratory of a Technical College. He should be able to keep the equipment in good condition, and to help with the design and manufacture of additional apparatus.

Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three testimonials, should reach the Principal on or before Friday, July 2nd, 1920.

JOHN J. JACKSON, B.A.,
City Hall, Director of Education.
Cardiff. H 186

CITY OF BRADFORD TECHNICAL COLLEGE.

APPOINTMENT OF ASSISTANT LECTURERS IN MECHANICAL ENGINEERING.

Applications are Invited for

ASSISTANT LECTURESHIPS in the Department of Mechanical Engineering. The following appointments will be made—

(I) One Assistant Lecturer specially qualified in Internal Combustion Engines and Motor Car Engineering.
(II) One Assistant Lecturer in Engineering Mechanics.
(III) One Assistant Lecturer with special qualifications in Engineering Drawing.

Salary in each case will be according to scale rising to a maximum of £400 per annum. In fixing the initial salary, consideration will be given to qualifications and previous experience. (In addition to the salary a bonus amounting at present to £85 16s. per annum is also paid.)

Applications, upon forms which may be obtained from the PRINCIPAL, Technical College, Bradford, should be forwarded not later than SATURDAY, 26TH JUNE, 1920.

BY ORDER.
H 251

UNIVERSITY OF LONDON.

GOLDSMITHS' COLLEGE, NEW CROSS, S.E. 14.

Applications are Invited for

the POSTS of:—

1. Evening Lecturer in Electrical Engineering, Grade II A.C.
2. Evening Lecturer in Electrical Engineering, Grade III.
3. Evening Assistant Instructor or Demonstrator in one or all of the following subjects:—Fitting and Machining (Precision work) Machine Drawing, Machine Design. Practical Mathematics.
4. Evening Instructor in Metal Plate Work, Grade II. (Drawing).
5. Evening Assistant Demonstrator in Electrical Engineering (Laboratory).

Remuneration according to the London County Council's scale of salaries.

Applications, stating qualifications, to be sent not later than 30th June, addressed to:—

THE WARDEN, Goldsmiths' College, New Cross, S.E. 14. H 213

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Further particulars and Forms of Application may be obtained from the undersigned, to whom completed Forms should be returned not later than 14th July, 1920.

A. C. BOYDE,
Director of Education and Secretary.
June, 1920. H 68

KENT EDUCATION COMMITTEE.

BRITH TECHNICAL INSTITUTE.

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E. SALTER DAVIES,
Director of Education.
28th May, 1920. G 909

HYDROGEN PRODUCTION FOR AIRSHIPS.

By P. L. TEED, A.R.S.M., A.I.M.M.

PRIOR to the war the only demand for hydrogen in large quantities in England was in the fat hardening industry and the plants in operation were comparatively few, and, as might be expected, by no means uniform in their method of operation, for manufacturers were not clear as to which was the best method of hydrogen production. In August, 1914, electrolytic and iron contact plants, were both in use, followed soon after by a Linde Frank Caro water gas liquifaction plant which was completed and put into operation by Messrs. Ardol, of Selby.

In Germany, largely owing to the national faith in airships which had existed with increasing conviction during the previous ten years, hydrogen production was on a far bigger scale. Many processes had been tried and large scale units were operating on the following systems, electrolytic, iron contact, water gas liquifaction (Linde Frank Caro), and water gas oxidation (Bamag Catalytic), while at least two small experimental plants were working, one on the Bergius iron contact system, and another on the Carbonium process of decomposing acetylene.

In America, before the war, hydrogen production was practically confined to the requirements of the fat hardening industry, and the processes in operation were limited to the electrolytic and iron contact ones.

The principle of the eletrolytic process is well known, and there are numerous standard units which produce approximately 6 cub. ft. of hydrogen and 3 cub. ft. of oxygen per kw.-hour, which, with a coal consumption of 2 lb. of fuel per kw. hour, is equivalent to 6,720 cub. ft. of hydrogen, and half as much oxygen per ton of coal consumed. The purity of the hydrogen is generally over 99·5 per cent., containing as an impurity chiefly oxygen (also traces of hydro-carbons if an alkaline electrolyte is used).

The iron contact process consists essentially of the alternate reduction of iron oxide by water gas and its subsequent oxidation by means of steam. If the whole of the fuel consumed in the plant is coke, both for steam raising (for all purposes) and for water gas manufacture, the yield of hydrogen is about 6,500 cub. ft. to 7,000 cub. ft. per ton of fuel. The majority of the numerous plants working on this principle give a hydrogen, after purification by passing through ferric hydrate and lime, of about 99 per cent., with about equal quantities of nitrogen and carbon monoxide and traces of sulphur compounds other than sulphuretted hydrogen.

The Linde Frank Caro process operates by liquifying all the constituents of water gas except hydrogen; the separated liquid gas, chiefly carbon monoxide (after re-evaporation, with consequent cooling of fresh, raw gas), is sufficient in plants of about 4,000 cub. ft. hydrogen capacity per hour, to supply all fuel necessary for the auxiliary machinery and steam raising for the water gas generators. With a coke consumption of 35 lb. per 1,000 cub. ft. of water gas, the hydrogen yield is about 25,000 cub. ft. per ton of coke. The hydrogen is about 97 per cent. by volume with 2 per cent. carbon monoxide, 1 per cent. of nitrogen; the gas is free from sulphur compounds.

The "Bamag Catalytic" process consists of oxidising the carbon monoxide of water gas with steam, in the presence of a catalyst, and then separating the resulting carbon dioxide from the hydrogen by passing the gas under pressure through water (Bedford method). With a consumption of 35 lb. of coke her 1,000 cub. ft. of water gas, the gas production is about 35,000 cub. ft. per ton, containing 97 per cent. hydrogen, 2·7 per cent. nitrogen, and 0·3 per cent. carbon monoxide, the gas being free from all sulphur compounds except traces of sulphuretted hydrogen which can, if necessary, be removed.

In the next column is given a tabular summary of the working results of industrial processes in use. It will be seen from this table that these processes have very differing efficiencies, and that very high purity hydrogen is obtained only at a very great fuel consumption.

Output of Industrial Processes for Hydrogen Production.

Type.	Yield per Ton of Fuel.	Purity by Volume.
Electrolytic ..	6,700 cub.ft. of H. 3,350 cub. ft. of O.	99·5 per cent. } Free from 98·5 per cent } sulphur compounds.
Iron contact ..	6,500 cub. ft. to 7,000 cub. ft. H.	99·0 per cent., with traces of sulphur compounds other than H_2S.
Linde Frank Caro	25,000 cub. ft. H.	97·0 per cent., free from sulphur compounds.
"Bamag Catalytic"	35,000 cub. ft. H.	97·0 per cent., free from sulphur compounds.

In England the war found the country practically without Government hydrogen plants (as the airship service was limited to seven distinctly inferior airships) with the result that it became necessary to indulge in the rapid construction of plants of more or less known reliability rather than those of higher efficiency whose detail was still somewhat experimental. The first plants constructed were Silicol ones. In this process powdered ferrosilicon (over 80 per cent. Si) is run into an aqueous solution of caustic soda (25 per cent. to 30 per cent. NaOH), when the following reaction takes place:—

$$2\,Si + 2\,NaOH + 3\,H_2O = Na_2Si_2O_5 + 4\,H_2.$$

In actual practice the consumption of caustic soda is about 12 per cent. more than that indicated in the above equation, and the hydrogen yield about 8 per cent. less. A ton of ferro-silicon (over 90 per cent. Si) gives about 45,000 cub. ft. to 50,000 cub. ft. of hydrogen of about 99·9 per cent. with traces of arsene, phosphene and acetylene.

This process has much to commend it, the capital cost of the plant for equal hourly yield is about one-fifteenth of that of the iron contact plant, the purity of the gas is higher, and the manipulation of the plant much more simple; but the cost of materials consumed for equal volumes is (at prices prevailing in 1918) seven times as high as in the iron contact process. On the other hand whenever hydrogen is required the plant can be got ready and put into operation within an hour, nothing whatever being required except caustic soda, ferro-silicon and water, together with a small amount of power (about 30 h.p. for a yield of 60,000 cub. ft. per hour) for pumping cooling water and driving stirring mechanism. Even the most rapidly started iron contact plant, the Messerschmitt, if water gas is available, requires about eight hours, starting from cold, before hydrogen can be produced.

The Silicol process is an ideal war method of producing hydrogen, and has been used by the Germans, French, Belgians, Americans and ourselves for the supply of hydrogen, chiefly for kite balloons, and also for small airships.

With the creation of airship bases of a permanent nature with a fairly steady hydrogen demand, the iron contact process, in its several forms, was adopted in both England and America, and has given most satisfactory results, even if they were secured with what, in the near future, will be regarded as high fuel consumption.

Industrially, there can be no doubt that the most effective process for hydrogen production to-day is the "Bamag Catelytic"; it gives a hydrogen free from all sulphur compounds, save traces of sulphuretted hydrogen, which if necessary, can be easily and cheaply removed. Research during the war has shown an effective method whereby the small quantity of carbon monoxide can be largely and satisfactorily eliminated; thus by this process fairly high purity hydrogen containing little except nitrogen as an impurity, can be continuously manufactured.

For commercial airships the question of a suitable process for hydrogen production is one of great complexity, as so much depends on the amount and regularity of the demand. To-day, the large hydrogen consumption of airships is due to two causes, one the necessity for valving hydrogen owing to increasing buoyancy arising from fuel consumption during flight, and the other owing to having to valve hydrogen owing to sudden increases in buoyancy due to superheating of the hydrogen by sunlight. Both the causes of hydrogen waste (if airships are operated commercially) will be, if not eliminated, then certainly reduced. Then the only hydrogen consumption will arise from outward diffusion of the gas through the gas bags and inward diffusion of air, which ultimately brings the purity of the remaining gas down to such an extent that it has to be replaced by fresh hydrogen. This source of hydrogen consumption is likely to decrease also, for, during the war the impermeability of fabric has enormously increased, and seems to be likely to be improved still more. Indeed, it is not allowing imagination to run riot to express a belief in the possibility of airships in the future having hydrogen requirements which will be negligible in comparison with those of to-day.

To turn to conditions as they exist to-day, the voyage of R. 34 serves as an example. We were officially informed that she left East Fortune with 5,000 gallons of petrol, and that she arrived at New York with about 100 gallons, that is to say, the decrease in weight of the ship was:—

$$4{,}900 \times 7.2 = 35{,}200\ \text{lb.}$$

Now since an airship must land in equilibrium (and cannot fly very much out of equilibrium) the total valving of hydrogen during the voyage from this cause would have amounted to (assuming, under the average conditions prevailing, that 1,000 cub. ft. of hydrogen had a lift of 65 lb.),

$$\frac{35{,}200 \times 1{,}000}{65} = 540{,}000\ \text{cub. ft.}$$

Combining this with superheating effects, it is improbable that in order to start on the return trip the total hydrogen required was under 700,000 cub. ft.

To supply this quantity of hydrogen rapidly and economically necessitates that it shall have been made prior to the arrival of the ship, and should be in storage in an ordinary spiral guide gas holder (which is the cheapest form of gas storage). To accumulate this volume of gas during a week would require a "Bamag Catelytic" unit of 4,000 cub. ft. per hour hydrogen capacity with a second unit of the same size in reserve.

Now assume that a certain place is visited by an airship occasionally, and not even at regular intervals in such a case the question of gas supply becomes very difficult. It is not possible to keep hydrogen for indefinite periods in low pressure holders, as there is always an inward diffusion of air which gradually lowers the purity, and will in course of time render the gas useless. The construction of a "Bamag Catelytic" type plant of large hourly capacity is a doubtful expedient, as the capital depreciation charges may entirely eliminate the actual material cheapness of the progress, and further, these plants owing to their large heat capacities, are not efficient when operated intermittently.

For large irregular demands for hydrogen it is doubtful if there is, to-day, any process more suitable than the Silicol one. Plants of 60,000 cub. ft. per hour capacity have been made, they can be rapidly set in operation and be operated by one engineer having a little chemical knowledge, assisted by navvy labour.

Though the Silicol process was regarded as a purely wartime method, it is most probable that in the early days of commercial airships, when hydrogen demands will be both large and irregular, it will continue to play a useful part; but should commercial airships become regular in their services, a more efficient process will doubtless replace it if the present consumption continues. However, it is not improbable that the condensation of the water in the exhaust of the airship petrol engines (100 lb. of petrol produces 145 lb. of water on combustion) will eliminate the present consumption of hydrogen due to valving from excessive buoyancy due to fuel consumption, and that improvements in the outer cover of rigid airships will also greatly reduce the present superheating losses. Thus airships may have such small hydrogen requirements that at all stopping places (except the main base), the production of hydrogen will be more influenced by the capital cost of the plant than the material cost of the hydrogen.

THE BIRKENHEAD WORKS OF MESSRS. CAMMELL LAIRD AND CO., LIMITED.

LIVERPOOL is pre-eminently a seaport, and although many large and important works of very miscellaneous type exist either in the city, or its environs, it is essentially as a shipping centre that the town is famous. For this reason Liverpool is not an engineers' town in the sense that Birmingham is. It must, however, always be a centre of great interest to engineers in view of the shipping and the docks which accommodate it. These are both the creation of engineers, and the branches of engineering connected with ships and shipping may certainly be studied with great profit in Liverpool, so that the meeting which the Institution of Naval Architects is to hold in the city in July should be enjoyable and profitable. Liverpool not being an engineers' town from the manufacturing point of view, there will not be the variety of engineering establishments available for visits which a corresponding summer meeting at Glasgow would find, but such establishments are very far from entirely lacking and very especially, in connection with the works of Messrs. Cammell Laird and Co., Limited, is an establishment available which has much of great interest to show.

We do not know that antiquity is in the nature of a virtue, but some special interest always resides in an establishment, or an institution, which has had the vitality to outlive most of those which were once its fellows. We think we are correct in saying that the record of the Birkenhead shipyard is passed only in length of days by Messrs. Scotts of Greenock and Messrs. Palmers of Jarrow-on-Tyne. The name Laird is so interwoven with the history of English shipbuilding that it is hardly possible to begin a description of Messrs. Cammell Lairds' present establishment without some little reference to earlier days, although it is far from our present intention to attempt a history of the yard. When dealing with a firm which has produced such famous ships as the Birkenhead, the Captain and the Alabama, it is not possible, however, entirely to ignore the past.

The shipbuilding industry was established on the Mersey in 1824 by William Laird, the original works being at Wallasey Pool with a branch establishment on the Liverpool side of the river, on a site now occupied by the Herculaneum Dock. The activities of the firm were at first confined to the building of ships and boilers, but engine works were added in 1857 after removal to the present site at Birkenhead. The firm of Charles Cammell and Co., which was founded in Sheffield in 1837, purchased the business of Laird Brothers in 1903, and the joint firm then took its present title. At this time the shipyard and engine works covered an area of some 25 acres, but in 1905 large extensions were taken in hand and the adjacent Tranmere Bay estate was developed and laid out. The present establishment, of which a plan is given in Fig. 1, on page 813, accordingly covers about 108 acres. In connection with this plan it may be of interest to point out here that the original yard covered the northern part of the present works, and that some of the graving docks which are to be seen at that end of the site are now approaching a century of service.

The historical aspects of this famous yard performing merely introductory service in this article, we make no attempt even to summarise the contributions which the Birkenhead establishment has made to the progress both of the mercantile and naval services. It is of interest, however, to point out that if Laird Brothers were not the first they were of the first to build iron ships, and that the first iron vessels navigated in the seas of India, China, the United States and Egypt were built by them. The firm built its first screw steamer in 1838, the very early days of screw propulsion. She was named the Robert F. Stockton, after her owner, an American. The boat was ultimately taken to the United States and her name changed to New Jersey. Excepting an experimental craft, she was the first screw vessel in the United States. What was we believe the first steel steamer to be constructed was built at Birkenhead. She was a river boat, 75 ft. long, and was used by Livingstone in African expeditionary work. The firm did much valuable work in the early days of ocean-going steamers and liners, and built many ships for the P. and O. Service, the Cunard Line, &c. In the latter years of the last century, however, the growth in length of this class of vessel was such that they could not well be undertaken on the Birkenhead slips, and the firm for some years specialised in cross-Channel steamers and war craft. The incorporation of the Tranmere estate altered this condition of affairs, and at the present time a very representative collection of merchant vessels is to be seen in progress of various sizes up to and including a 600-ft. Cunarder.

In warship building, Messrs. Cammell Laird have always taken a prominent place, the first Admiralty contract with the old works dating from 1839. From that date to the present time we believe the firm has built some 130 warships of various types for the British Admiralty. We make no attempt to enumerate what these figures cover, but it may be of interest to say the Birkenhead, whose name stands for one of our noblest stories of the sea, was a wooden frigate, 210 ft. long, and with machinery of 560 h.p. She was built in 1846. The Captain, whose story is equally remembered, but with less national pride, was a low freeboard turret ship, built in 1871. Her unhappy loss in no way stands against the name of her builders. In later years the firm was concerned in all the various building programmes and constructed examples of most of the types of cruiser and battleship which have led to our present standards. Their actual war work we will refer to in a moment, but of their later pre-war vessels that whose name has perhaps achieved the greatest prominence was H.M.S. Audacious, of peculiar memory. To the firm's warship work for other countries we can do no more than refer. It is perhaps, however, allowable to say that the famous Alabama was a vessel of 214 ft. long and with a speed of 12 knots. She was built in 1860.

At the outbreak of war, Messrs. Cammell Laird had under construction, among other vessels, three cruisers and one flotilla leader. As vessels of these classes were from the first of the greatest value, special efforts were at once made to complete those in hand in the shortest possible time. As a result the cruiser H.M.S. Caroline was delivered to the Admiralty 5½ months before her contract time, and the flotilla leader H.M.S. Kempenfelt was similarly delivered four months before her contract date. The Caroline was followed by seven similar vessels, each of which was completed in twelve months, as compared with the usual pre-war time of from eighteen to twenty months. The Kempenfelt was followed by 16 flotilla leaders. In connection with this type of ship it may be mentioned that H.M.S. Swift, the pioneer of the type, which did such distinguished service on the Dover Patrol, was built by Messrs. Cammell Laird in 1907. In addition, the firm also built during the war 10 submarines and 10 merchant vessels, which included among their number three large ships originally intended as liners and three of the largest type of standard ship. In addition to these various complete vessels, the turbine machinery for two cruisers was also built during the war.

This record of their work completed makes up to a very considerable total, but is far from representing the whole of the war work carried out at Birkenhead. Owing partly to the special experience of the firm in connection with repair work and partly to the convenient situation of the yard, a very large amount of work of a reconditioning nature was allotted to Messrs. Cammell Laird, and the yard was made the repairing and refitting base for the American destroyers operating in European waters. The reconditioning and repair work covered some heavy jobs, and included such matters as the reparation of damage caused by mines and torpedoes or collisions, extensive refits to ships with the installation of guns and special machinery, the fitting out of vessels as transports, seaplane carriers, &c. One of the most interesting pieces of work carried out was the conversion of the liner Campania to a seaplane ship. In all 602 vessels were dealt with in one way or another, 502 of them being repaired or altered at Birkenhead and the remainder being dealt with by the firm and the firm's workpeople at Royal Dockyards.

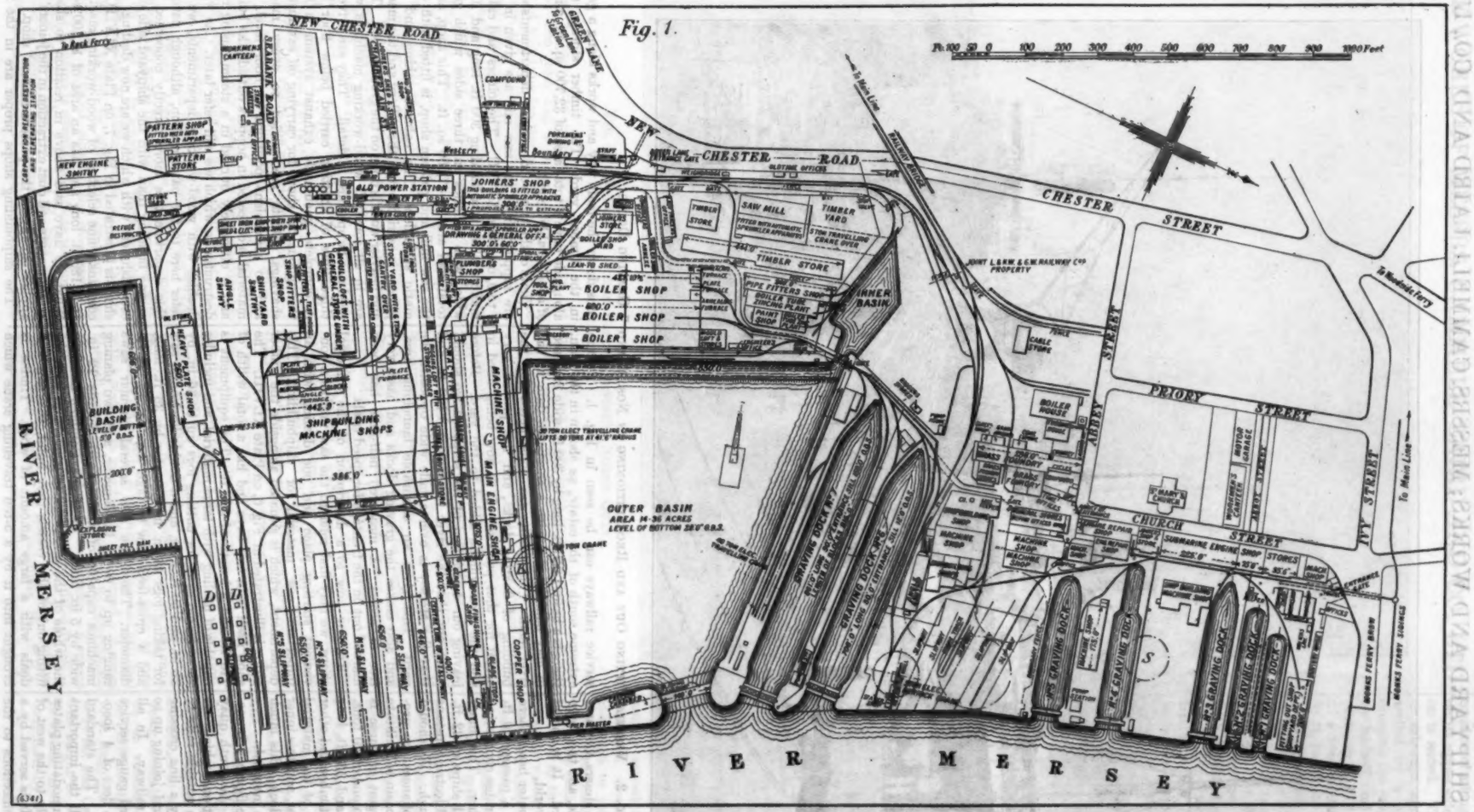
Coming now to a description of the shipyard and engine works as they now exist, we may first refer to the plan given in Fig. 1. As will be seen, the yard lies on two sides of a fitting-out basin which has an area of 14 acres and an entrance from the river 140 ft. wide. The larger slipways and shops are to the south side, while the graving dock and some of the smaller shops are to the north. The two large graving docks, respectively 861 ft. and 708 ft. long, form part of the 1905 extensions. The smaller graving docks are in what was the original yard. It is hardly necessary to point out that there are but few private shipyards which have graving dock accommodation equal to that shown in Fig. 1, and that this equipment places the firm in a very favourable position for undertaking reconditioning and repair work, of which naturally much is required in connection with a port of the size of Liverpool. This class of work forms such an important feature of Messrs. Cammell Laird's activities that the north end of the yard is devoted exclusively to it. This part of the establishment is run as a separate works, in as far as the operatives are concerned, so that there is no interference between repair jobs and the main shipbuilding programme. Engine repairs are confined to special shops which can be seen on the plan, and work of this class, unless it be of a specially heavy nature, is excluded from the main machine shops. Views of the two large graving docks are given in Figs. 2 and 3, on pages 814 and 815. These views are taken looking towards the river. The steamer on the right, in Fig. 3, is lying in the outer basin. A view showing the river entrance to the graving docks and outer basin is given in Fig. 4, on page 816.

At the south side of the yard there are six slipways. The longest of these, No. 6, can be arranged to accommodate a ship 1,000 ft. long. This way was occupied during the later stages of the war by a battle-cruiser, a sister ship to H.M.S. Hood. After the armistice work was suspended and the partially completed hull was finally broken up. The slipway is now occupied by a new intermediate Cunard liner of 600 ft. long and a gross tonnage of 21,000. The hull is now well under way, and the boat should be launched in the autumn of this year. A view showing the hull under construction is given in Fig. 5, on page 816. The slipway is equipped with electrically-operated derricks built by Messrs. Sir William Arrol and Co., Limited, of Glasgow, and lifting 6 tons at 60 ft. radius. The slipways are all piled, as indeed are all heavy foundations throughout the newer part of the works, the whole area consisting of made ground. To the north of the outer basin there are further slipways shown in our plan. These are capable of taking vessels from 300 ft. to 350 ft. long. They were occupied during the whole of the war with the building of destroyers. We should say that three of the slipways are now being converted so that two will in the future occupy the space of the three. This is being done in order that a rather larger type of vessel than a torpedo-boat destroyer may be dealt with. The two new slipways will be served by a pair of fixed Toplis derrick cranes with revolving heads and of a capacity of 4 tons each at 105 ft. These cranes, which were built by Messrs. Stothert and Pitt, Limited, of Bath, originally for the Chepstow shipyard, will be able to serve every point on the two slipways.

The extent of the graving dock accommodation is so well shown on the plan that little need be said about it. As will be seen, the largest dock has a length of 861 ft. and a 90-ft. entrance. The depth of water on the sill during spring tides is 35 ft. The corresponding figures for the dock next in size are 708 ft. long and 80 ft. entrance, the depth of water on the sill being 32 ft. A steam driven pumping station situated on the pier head between these two docks serves for emptying either. The five smaller graving docks range in length up to 448 ft. 6 in., in width up to 83 ft. 3 in., and have a depth of water on the sill at spring tides up to 21 ft. 9 in. As the height between high and low tides in the Mersey is very considerable, these older graving docks have in the past been emptied naturally by waiting for the fall of the tide. A

THE BIRKENHEAD SHIPYARD AND ENGINE WORKS OF MESSRS. CAMMELL LAIRD AND CO., LTD.

Fig. 1.



drainage pumping plant to complete the emptying and deal with leakage has always been in use. Modern electrically-driven pumps have now been installed for the three larger docks. The new plant will enable the docks to be emptied more rapidly than in the past, in about 2½ hours, and will correspondingly extend their utility. Between the two larger graving docks there is an electric travelling crane lifting 40 tons at 78 ft. radius. The crane has been fitted with an extension to the jib by Messrs. Cammell Laird, so that in addition to its original capacity of 40 tons at 78 ft. radius it can now also deal with loads up to 10 tons at 108 ft. radius.

The outer basin has an area of 14·36 acres and the depth of water is 40 ft. at spring tides and 31 ft. at neap tides. The river entrance is 140 ft. wide, and is closed by a sliding caisson which is hauled to and fro by an electric winch. Arrangements are made so that the caisson may be pumped out until it floats, or filled with water so that it may sink in position. The outer basin may be looked upon as one of the special features of the works, and is obviously of great value in connection with the fitting out of ships. A large amount of quay length is available. The south quay is fitted with a 150-ton fixed crane for lifting heavy pieces of machinery into ships under construction. The crane will lift 150 tons 52 ft. 6 in. clear of the wall, or 50 tons 88 ft. 6 in. clear. On the same quay there is a 30-ton travelling crane with a radius of 41 ft. 6 in. The crane has been lifted 25 ft. by Messrs. Cammell Laird's works department, and is now being fitted with a new jib with an extension for a 5-ton auxiliary block, so that it will lift 5 tons at 95 ft. radius. The crane was originally purchased for destroyer work, and has been modified to make it suitable for merchant shipbuilding. As will be seen from the plan, the fitting-out quay with its cranes is immediately contiguous to the main machine shops, so that heavy engine parts may be taken almost directly from the shops to the vessel for which they are intended. The same quay is also close to the boiler shops, from which it is reached by the service railway as indicated in Fig. 1. In addition to the two cranes dealt with above the 40-ton travelling crane now situated between No. 6 and No. 7 graving docks was originally fixed on the north wall of the outer basin, and so was available for fitting-out work. Prior to its removal, however, the lifting capacity available in the basin was strengthened by the delivery of a floating crane of 200 tons capacity at 65 ft. clear of the pontoon, or 30 tons at 97 ft. 6 in. on an auxiliary block. There is also a travelling monkey underneath the jib for use in full-out position for lifting and travelling

THE BIRKENHEAD SHIPYARD AND WORKS; MESSRS. CAMMELL LAIRD AND CO., LTD.

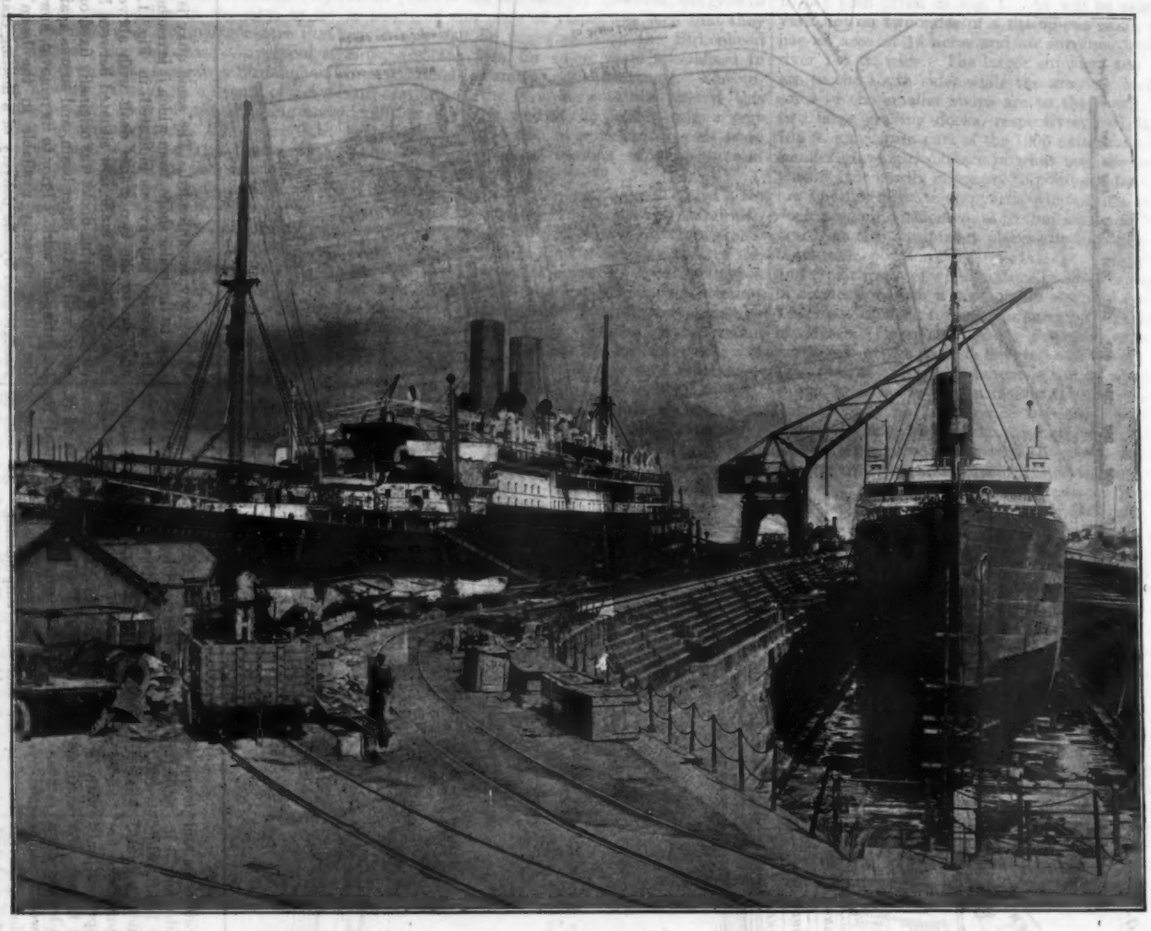


FIG. 2. VESSELS FITTING OUT AND RECONDITIONING IN NOS. 6 AND 7 GRAVING DOCKS.

5 tons. The crane was supplied by Messrs. Cowans, Sheldon and Co., Limited, of Carlisle, and the barge was built by Messrs. Cammell Laird. It is one of the largest floating cranes in the world.

At the north-west corner of the outer basin there is an inner basin, reached through a passage 40 ft. wide which is spanned by a swing bridge connecting the two parts of the yard together. This inner basin has an area of 2¼ acres, and ships of 22 ft. draught can traverse the passage. Electric capstans are provided for warping ships through. We should have said earlier that similar appliances are provided in connection with the outer basin to facilitate the movement of ships. The largest of these is of 35 tons capacity and there is also one of 20 tons. The inner basin has quays 450 ft. and 350 ft. long and is utilised for the importing of timber and other supplies. A considerable portion of the material received at the yard comes by water, and this inner basin, which is in effect a private dock, adds much to the convenience of handling this material.

The timber store, as shown in the figure, is immediately alongside the basin, while the south quay is served by the railway connections which are carried throughout the yard. The outside railway connection to the works is made by a line crossing the new Chester-road by a bridge and joining up to the Birkenhead and Chester joint railway. In all there are about 6 miles of standard gauge service railway in the works which carry a fleet of 4 locomotives and 22 locomotive cranes. The standard gauge lines are carried through all the important shops. The main stockyard, accommodating plates and sections, is situated immediately to the west of the shipbuilding machine shops. It is served by a 6-ton travelling gantry, and its connections to the service railways can be seen in Fig. 1. At the extreme south of the estate, as shown in the plan, there is a basin 1,050 ft. long by 300 ft. wide enclosed in clay banking and with a sheet-pile dam at the river end. This basin was constructed for the building of floating docks, and has proved very useful for that purpose. It is now being filled in and the area will be added to the yard. Before leaving our description of the shipyard we should point out that the river frontage is 3,100 ft. and that the Mersey is over a mile wide opposite the yard. This gives an admirable launching area, and also makes the graving docks and bases very free of access. A measured half-mile has been marked out on the frontage for speed trials.

Turning now to a description of the principal shops, we may first refer to the saw mill as a convenient starting place and one dealing with an important raw material of shipbuilding. This department, which is situated alongside the timber store, is illustrated in Fig. 6, on Plate XLVIII. The shop itself is in two bays and has a total width of 110 ft. and a length of 200 ft. The equipment is capable of dealing with large material, and includes three frame saws for cutting logs up to 36 in. by 36 in. and 50 ft. long, and a double horizontal saw for taking logs 48 in. in diameter by 36 ft. long, and a cross-feed saw to take logs up to 24 in. diameter. There are also several circular saws ranging up to 60 in. in diameter, and two planing machines capable of dealing with boards 12 in. wide by 5 in. thick. As Messrs. Cammell Laird do the whole of the woodwork in connection with the fitting-out of the vessels they build, this saw mill deals with a large amount of work. Timber is brought into it by a 5-ton travelling crane which runs down the main bay and works along a gantry in the timber yard. The timber storage sheds alongside have a total area of 32,700 sq. ft. and are of considerable height.

Views of the two wood-working departments which are supplied from the saw mill are given in Figs. 7 to 9, on Plate XLVIII. The joiners' and cabinet-makers' shop is a building 300 ft. long and 100 ft. wide, with galleries on three sides which give a total floor area of 47,000 sq. ft. This shop, as also the saw mill and pattern shop, is fitted with automatic sprinklers. The cabinet-making and light joinery is carried out in the gallery and the machine and heavier work is done on the ground floor. There are in all some 50 wood-working machines which need not be specified in detail. They are driven by three lines of shafting carried below floor level. A complete pneumatic exhaust system is fitted throughout the shops for carrying off sawdust and shavings. Ducts are carried to every machine and to convenient positions at floor level. The material is collected in hoppers outside the building and is ultimately burned in a steam-raising refuse destructor to which we will refer later. As we are dealing with wood-working departments, we may refer here to the pattern shop, although naturally this department is more directly concerned with engine building than with the shipyard side of the establishment with which we are now dealing. The shop is illustrated in Fig. 7, on Plate XLVIII, and contains a fine selection of wood-working machines. It is 180 ft. long and has an area of 17,100 sq. ft. What we have said above in relation to shafting arrangements and dust extraction in the joiners' shop applies equally in the pattern-makers' shop.

The shipbuilding shops proper are in the main

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FIG. 3.—VESSEL IN OUTER BASIN ALONGSIDE NORTH QUAY.

grouped to the landward end of the slipways. It will be seen from Fig. 1 that there are separate shops of this type for the main slipways south of the basin and for the smaller slipways to the north. We shall confine our detailed reference to the main south shops. Operations from the pure shipbuilding point of view may be considered to begin at the moulding loft, which is situated above a general store, as shown in the plan. In this loft, which has an area of 19,600 sq. ft., the lines and sections of ships are drawn out on the floor and templates are made. The machine shop for dealing with plates, angles and bars are illustrated in Figs. 10 and 11, on Plate XLIX. As is indicated by the illustrations, this is a very fine shop, and is indeed one of the largest of its kind in the country, having a total roofed area of over 150,000 sq. ft. The very large amount of room round the various machines, giving plenty of space for handling, may be looked upon as one of its special features. As will be seen from the figures, the roof stanchions are a considerable distance apart, giving a good clear floor. The bending blocks and screeve boards are shown in Fig. 10. They each have an area of about 17,000 sq. ft. Adjacent there are the gas-fired furnaces. There are two angle furnaces which can deal with bars up to 60 ft. in length. There are also two furnaces capable of taking plates up to 7 ft. 2 in. by 28 ft. As will be clear from the plan, these furnaces are situated close to the stockyard. A bevelling machine is situated alongside the furnaces on which angles, channels and Z bars may be bevelled as required before passing to the bending blocks. An assemblage of portable hydraulic bending machines is available to assist manual labour on the bending blocks.

A view showing part of the machine equipment of this shop is given in Fig. 11. We do not propose to attempt to deal with this equipment in detail, but would say that in general it is designed to deal with plates up to 36 ft. long by 7 ft. wide by 2 in. thick. There are in all about 30 punching and shearing machines of various capacities up to machines for shearing 2-in. plates and punching 2-in. holes in 2-in. plates. The larger of the tools are fitted with hydraulic jib cranes, and all are independently driven by electric motors. There are also three batteries of radial drilling machines with 15 drills having a spindle radius of 9 ft., and four batteries of countersinking drills each arranged to deal with plates 36 ft. long by 7 ft. wide at one setting. Other plate-working machinery consists of three double-headed scarphing machines, each served by a 4-ton hydraulic pedestal crane of 26 ft. radius, and two hydraulic joggling machines which can deal with plates $\frac{3}{4}$ in. thick in one operation. There is also a hydraulic manhole punching machine suitable for making holes up to 42 in. by 16 in. in $\frac{1}{2}$-in. plate. For flat plate work there are two multiple punching machines which can form at one stroke 18 holes up to $\frac{11}{16}$ in. in diameter, and can deal with a plate 35 ft. long by 7 ft. 3 in. broad. A series of small levers enables any punch to be individually thrown in or out of action for any stroke. A recent addition is a punching machine fitted with a Lysholm traversing table made by the Norbom Engineering Company of Philadelphia, Pa., U.S.A. This arrangement, of which illustrations and a description have already appeared in our columns,* consists of a long frame carrying a number of wheels on its upper side on which the plate to be operated on is rested. The frame can travel either endwise or sideways, and its movements are entirely controlled by a man who sits at the centre. He operates the punching machine by a pedal, and can by himself deal with the complete punching of a plate up to 30 ft. by 8 ft. Other machines consist of a keel plate bender capable of bending plates 35 ft. long by $\frac{3}{4}$ in. thick, and various machines for working angles, channels and bull irons.

The various plates and other parts which are dealt with in this main shop pass directly to the various slipways. As shown in Fig. 1, the path is a short and direct one. Additional facilities in connection with the handling of very heavy plate are, however, provided by the heavy plate shop situated at the landward end of No. 6 slipway. This shop was built more particularly for dealing with the heavy plates which had to be handled in connection with the building of battleships, but is equally useful, especially in connection with the long slipway, for heavy plates required in large merchant ship construction. The various shops dealing with the smaller and miscellaneous parts required in the construction of hulls are situated behind the main shops, as shown in the plan. Of these the angle smithy deals with some of the lighter plates as well as angles. It is a building 210 ft. long by 114 ft. wide and contains punching and shearing machines, plate rolls and special rolls for dealing with plates to be built up into masts. The shop also contains plate edge planers, drills and a hydraulic bending machine for angles. The shipyard smithy is 255 ft. long by 70 ft. wide. It contains 50 fires, with 11 pneumatic or steam hammers ranging in power from 3 cwt. up to 30 cwt. The steam hammers are run from a boiler connected to a Meldrum destructor, which is fired with shop and yard refuse and also with the sawdust and shavings collected by the exhaust plant from the various wood-working departments. As the steam is required continuously the destructor has at times to be fired with a certain amount of coal when refuse runs short. It has proved itself capable of dealing with fuel of very remarkably low grade.

Other shops concerned in the shipbuilding side of the works' activities are the ship-fitters' and the plumbers' departments. The ship-fitters' shop covers an area of 14,700 sq. ft. It is 210 ft. long and is served throughout its length by a 5-ton overhead electric crane. There are some 80 machines in this shop, including lathes, planers, drilling and milling machines, slotting machines, &c. This shop deals with the various engineering fittings required in the construction of the hulls of ships, such as valves, bulkhead doors, ports, &c. The plumbers' shop covers an area of 7,000 sq. ft. It is fitted with four sets of bending blocks with fires, and contains a machine plant consisting of screwing machines, grinders, saws, &c., suitable for dealing with pipes. The shops we have now dealt with cover the main departments concerned with shipbuilding, although there are various other ancillary departments which are arranged about the main shops. These, which do not require detailed reference, cover such branches of work as rigging, sheet-iron working, &c.

We may now pass to a consideration of the various departments which are more immediately concerned with the production of the propelling machinery of ships as distinct from the hull. The pattern shop we have already mentioned, and in view of its size and importance we may at once refer to the main engine and machine shop, of which a good view is given in Fig. 12, on Plate L. This shop, as will be seen from the plan, runs parallel to the longest of the wharves of the fitting-out bases and close to the cranes to which we have already referred, these being available for lifting heavy machine parts on to vessels under construction. The shop is divided into three bays, of which the centre has a total length of 1,075 ft. The width of this bay is 77 ft., and the height to crane-rail level is 63 ft. The height to the lowest part of the roof is 74 ft. It will be clear from these dimensions, and will be confirmed by Fig. 12, that this shop is an excep-

* See ENGINEERING, vol. civ, page 641.

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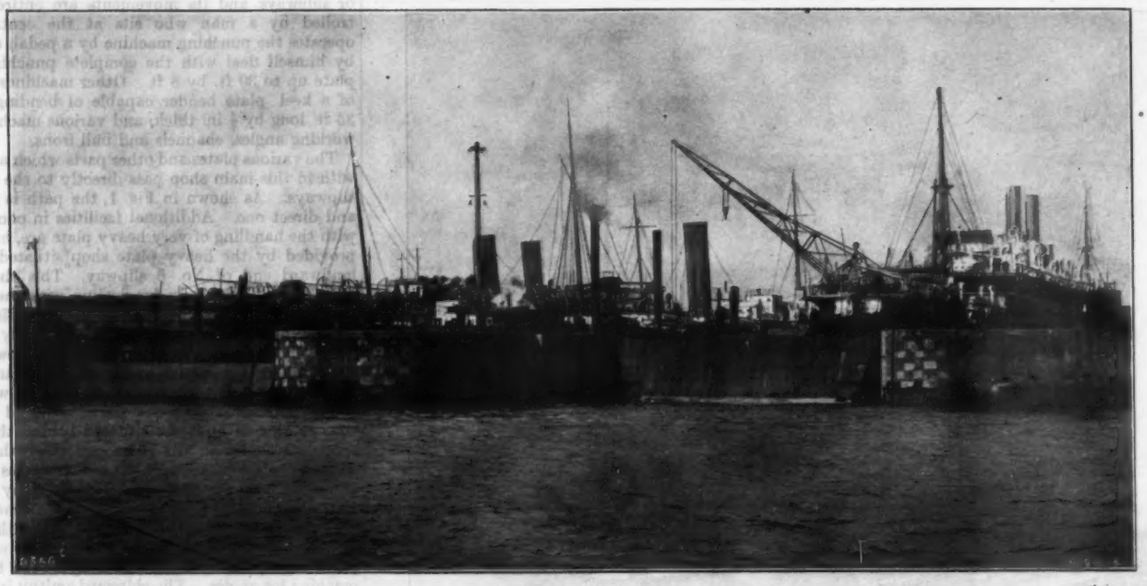

FIG. 4. RIVER ENTRANCE TO GRAVING DOCKS.

tionally fine one. The two side bays are each 42 ft. 6 in. wide with a height to crane level of 42 ft. 6 in. and to the underside of the roof of 50 ft. 4 in. The north bay, as will be seen, is broken in the centre to allow clearance for the 150-ton wharf crane, while the south bay is not carried quite to the full length of the main bay.

The main bay of this shop is used for erecting purposes and also contains most of the large machine tools, as will be seen from Fig. 12. It is traversed by one 100-ton, two 70-ton and two 20-ton electrically-driven overhead cranes, while attached to the columns carrying the roof and crane rails there are in addition ten 5-ton jib cranes of 30 ft. radius. The western ends of the side bays are devoted to engine building and machining work; the length of the north bay so concerned being 520 ft. and of the south bay 580 ft. The north bay contains most of the moderate-sized machine tools, while the south is devoted to the lighter work and contains an extensive plant of automatic and other machines. The former bay has 35-ton and 10-ton overhead travellers, and the latter similar appliances of 10-ton and 3-ton capacities. A standard gauge railway is carried right through the main bay, while narrow gauge shop railways with turntables and cross-connections run down all three bays. Egress to the wharf is provided at various points in the length of the bays. The east end of the north bay is used as a coppersmiths' shop, while the brass-finishing shop is situated at the corresponding end of the south bay.

The heavier of the machine tools are mostly situated towards the west end of the centre bay, from which the view given in Fig. 12 is taken. As we are not writing a specification we need not give a list of this machinery equipment, but it should be said that some very fine tools of the larger class are to be seen in the shop. Among the lathes, which are of course equipped for dealing in the main with marine turbine work, there is one of 92 in. centres and capable of taking a job 50 ft. long. Another has a 40-ft. bed and 66-in. centres, while a third, faceplate lathe, is of 50-in. centres and has a bed 40 ft. long. There is also a large chuck lathe used for low-pressure drums which is capable of dealing with a job 12 ft. in diameter. Among the planing machines there is a wall-creeper with a horizontal travel of 24 ft. and a vertical range of 19 ft. Another similar tool has a travel of 21 ft. and a vertical range of 15 ft. A planing machine suitable for dealing with bed-plates and similar parts, and which has a fixed table with traversing side pillars and cross-arm, is capable of dealing with work 30 ft. long by 20 ft. wide by 10 ft. high. It has four tool boxes. There are various boring machines, one of the largest taking a casting 17 ft. diameter by 50 ft. long and others being capable of dealing with work 15 ft., 12 ft. 6 in. and 10 ft. in diameter respectively. There are various boring or tapping machines, in one of which the spindle has a 16-ft. horizontal travel and a 13-ft. vertical travel, and four large radial drilling machines.

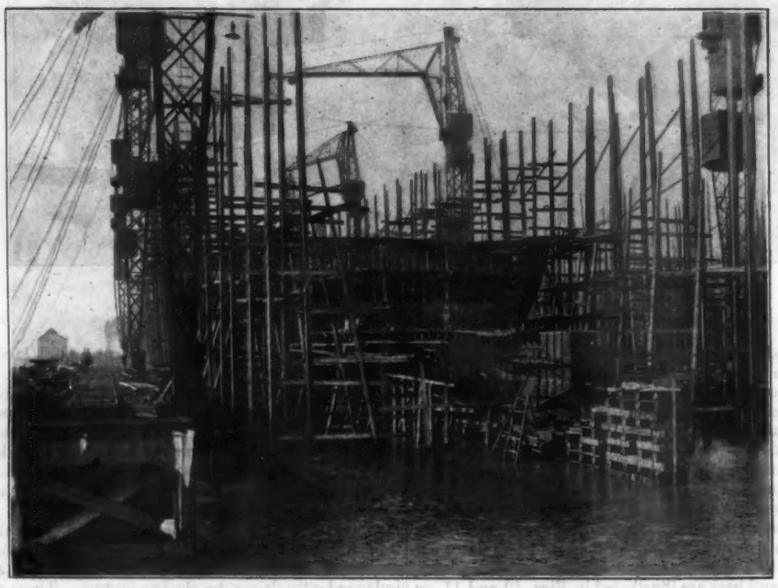

FIG. 5. CUNARD LINER ON NO. 6 SLIPWAY.

The shops contain a large plant of Muir's gear-cutting machines, engaged on the manufacture of wheels for marine reduction gears. This is a branch of marine work on which Messrs. Cammell Laird have had extensive experience. They carried out a very large number of installations of this class during the war, and with great success, and a large number of sets are now passing through the shops for use both on ships built at Birkenhead and for outside customers. In view of the high quality of the gears turned out it is interesting to note that it is the firm's practice not to use the creep gear which is fitted to the gear-cutting machines. At the east end of the shop there is an installation of machines, of special type in most cases, for dealing with the manufacture of turbine blades. The machinery with which we have so far dealt is intended and chiefly employed for dealing with the main features of turbine work. The shops, however, contain in addition a large plant suitable for reciprocating engine parts and the various miscellaneous details such as governor gear, &c., which are required in turbine work. A considerable number of reciprocating marine sets are still built, and the shop contains a vertical boring machine suitable for dealing with cylinders up to 12 ft. in diameter; and a horizontal machine with a maximum height

of spindle of 6 ft. 6 in. and a horizontal traverse of 8 ft. A useful tool for dealing with columns, slide valves, &c., is a planer with two overhead tool boxes and two side-cutting boxes. It can deal with work up to 22 ft. long by 8 ft. by 8 ft. Among slotting machines there is one with a 7-ft. stroke and capable of dealing with work 6 ft. by 6 ft., another of 36-in. stroke and a third of 18-in. stroke, and suitable for work up to 6 ft. in diameter. This latter is particularly suitable for work on eccentric straps. There are also various other planing machines, one taking work 8 ft. by 12 ft. and another 5 ft. by 5 ft.

The large installation of machines for dealing with smaller parts such as steam chests, valves, special pipe connections, &c., we cannot refer to in detail. We may, however, mention that for the machining of shafting there is a range of lathes extending up to 80 ft. long and 22-in. centres. An interesting machine which should also be mentioned is one for milling propeller blades. It carries four cutters, the movement of which is controlled by a spiral race. It is capable of machining propellers up to 12 ft. in diameter. Among other special purpose machines are a pair of multi-spindle drills for condenser tube plates. The south bay, as we have already mentioned, is given up to light work. It contains a very comprehensive collection of lathes, planers, slotters, shapers, keyway cutting machines, millers, boring and facing machines, and gear cutters for worm, bevel and spur gearing. A screw-making department is contained in this part of the shop, and is fitted with a collection of turret lathes, screwing machines and automatics. Part of the bay is also formed into a tool-room which is divided off from the other parts of the shop. It contains the usual assortment of precision lathes, milling machines, &c., and a heat-treating department. Before leaving this shop we should say that about one-third of the length of the centre bay, contiguous to the 150-ton crane, serves as an erection department. The floor is laid with reinforced concrete, and it is the practice to erect turbines and other engines and lift them bodily on to the test beds. For test purposes there is an installation of double ended marine boilers, and for testing stop valves there is a special high-pressure boiler.

The east end of the south bay is shut off to form a brass-finishing shop. This department is always an important one in marine establishments, and in one dealing to any considerable extent with Admiralty contracts takes on even greater importance. The shop contains a representative collection of machines which we need not detail. There is an example of a novel machine tool, however, to which we would like to refer. This is intended for slotting condenser-tube ferrules and was referred to in Mr. Hamilton Gibson's recent paper read before the Institute of Marine Engineers. The description given was, however, somewhat brief. The machine was illustrated on page 700 of our issue of May 21 last. Its essential parts consist of a pair of rotating discs fixed on the same spindle and close together. A circular slotting saw revolves close up to the edge of the discs, which contain radial holes into which the ferrules are dropped by hand. As the ferrules are carried round they are moved across the track of the saw and slotted. This arrangement, as so far described, is an obvious and common one for slotting ferrules, screws, &c. The special and ingenious feature of the Cammell Laird machine is the method of holding the ferrules while they are being slotted. The radial holes in which they fit are made an easy fit for the ferrules so that the latter may be quickly inserted. One-half of each hole, however, is formed in a loose sliding piece dovetailed into one of the discs, and as the ferrules approach the saw the outer edges of these sliding pieces come in turn against a fixed cam-piece on the frame. This cam-piece forces the sliding-piece inward and so causes it to grip the ferrule and hold it tightly while it is being slotted. When the ferrule has passed the saw, the sliding-piece is free from the cam and the ferrule is released, and so drops out below. The machine is continuously running; it is simply fed by a boy who puts the ferrules into the radial holes when they are on the top side of the disc. The device is very ingenious and neat. The only other department directly connected with the engine-building side of the works to which we need specifically refer is the coppersmiths' shop, which is at the east end of the north bay. This department contains 12 furnaces for working copper pipes, three hydraulic bending machines capable of dealing with pipes up to 12 in. in diameter, testing plant, &c.

We may now deal with the boiler shop, of which illustrations are given in Figs. 13 to 15, on Plates L and LI. This is a very fine building, divided into three bays, the main one being 500 ft. long by 80 ft. wide, and having a height to the crane track of 80 ft. The west bay is 422 ft. long by 80 ft. wide, with a height of 35 ft., while the east bay is 50 ft. wide and 30 ft. high. The total width of the building is therefore 210 ft. and the area 94,860 sq. ft. Of our three illustrations, Figs. 13 and 14 show the main bay and Fig. 15 the west bay, which is mainly given over to flanging work. The main bay is fitted with 70-ton, 40-ton and 10-ton overhead electric travellers, the west bay with one 30-ton and two 10-ton overhead travellers and the east bay with one of 10 tons. Raw material enters the boiler shop from the north end and leaves by the south, either for the fitting-out berths or for shipment away. At the present time, in addition to boilers for ships being built at Birkenhead, a large amount of boiler work for other firms both at home and abroad is being carried out and the boiler shop is one of the busiest in the whole establishment. The work is now mostly on marine boilers of the Scotch type, as shown in our illustrations, but the shops are adapted for building boilers of any class, and corresponding photographs to those we publish, if taken during the war, would have shown the bays full of water-tube boilers. The machinery throughout the shops is of modern type and the whole plant forms a most excellent example of a present-day boiler-making equipment.

As this description of Messrs. Cammell Laird's establishment has already extended to considerable length we will make no attempt to give a detailed description of the machine tool equipment of the boiler shop. We may, however, refer to some of the larger tools as, for instance, the plate-edge planing machine, which can be seen to the left in Fig. 13. This is capable of dealing with a plate 40 ft. long. The plate is clamped by a series of hydraulic cylinders. To the right of this figure, but hardly so well shown, there are a set of vertical rolls for forming the outer plates for cylindrical boilers. It is capable of dealing with plates 40 ft. long, 13 ft. wide and 1⅞ in. thick. The flanging bay contains a series of hydraulic presses of which the largest is able to deal with plates 3½ in. thick. It has three vertical rams, two acting on the plate from above and one from below. A 5-ton jib crane is provided above the machine.

Before passing on to deal with the power-supply arrangements and some other of the general features of the works, there are one or two other shops to which we should make reference. One of these is the marine oil-engine department illustrated in Fig. 16 on Plate LI. This shop is situated in the north part of the yard, and is lettered "Submarine Engine Shop" in our plan. This name, which the shop still carries, indicates the type of service on which it was engaged during the war. The shop is now devoted to the construction of the Cammell-laird-Fullagar marine oil engine, and two sets of the type are to be seen in the foreground, in Fig. 16. We need not enter into details of the construction of this engine, since we published a full description of it in our issue of January 30 last. The development of this engine illustrates the fact that the firm of Cammell Laird has not lost the pioneering instinct which has caused its name to be closely associated with so many important advances in the past. This is further illustrated by the fact that the first engine of this type has been fitted to the all-welded ship Fullagar, which was launched by Messrs. Cammell Laird last February. The ship has since carried out very successful trials. She has been in every way satisfactory, but is naturally in the nature of an experiment, and is intended more to illustrate and determine what can be done with electric welding in ship construction than to suggest that the method is at all points superior to riveting. Of our figures illustrating the shops the only one now remaining for mention is Fig. 17, on Plate LI, which is a view in the foundry. This shop has an area of 15,900 sq. ft., and is capable of dealing with castings up to 3 tons weight. There are three overhead travellers of 10 tons capacity. The shop is equipped with 22 crucible furnaces, drying ovens, grinding and mixing mills, &c.

The whole of the power supply for the shipyard and engine works is obtained from two generating stations, one of which is situated close to the stock-yard and the other, and newer, station alongside the foundry. No power is purchased from outside. The original station was entirely equipped with gas engines supplied from a Mond plant with washers and scrubbers, and was built at the time the Tranmere estate was developed and the old yard was extended. The producers also supplied gas to the furnaces in the platers' and other shops. This gas station was of considerable interest. Prior to the war the plant consisted of four 10-ft. Mond recovery-type producers with washers and a gas-holder. Gas was supplied direct from the holder to two angle furnaces and two plate furnaces. For the engines the gas was further cleaned by fans and passed through scrubbers filled with wood waste. The gas engines driving electric generators were 10 in number, varying in size from 140 kw. to 500 kw. Five were of the horizontal type and five were multi-cylinder vertical. The total capacity was 2,500 kw. There were also five gas-engine driven air-compressor sets of a total capacity of 6,600 cub. ft., of free air per minute at 100 lb. per square inch gauge, and four hydraulic sets, two driven by electric motors and two by gas engines. The total capacity was 240 gallons a minute at 1,500 lb. per square inch. Auxiliary plant included two electrically-driven starting compressors, each delivering 65 cub. ft. of free air per minute at 300 lb. per square inch, cooling towers for the washing water and jacket water, &c.

This interesting gas station has done good service in the past, but, as will be evident, the large number of comparatively small gas-driven units has resulted in a considerable maintenance charge. There has also been difficulty at times during the war in obtaining suitable fuel for the producers. These conditions combined with a growing demand for power have resulted in a decision to shut the gas station down altogether and to transfer all power generation to the new turbine station to which we have already referred. The gas station is now being dismantled. An annexe has been built alongside it, and fitted with two 1,000-kw. rotary converters, which are supplied with three-phase current at 3,300 volts from the turbine station. These converters supplying direct current from approximately the same point as the old gas station, feed into the existing network and do not involve change in the distributing system. The hydraulic plant in the old station is being retained, but is being converted to electric drive through single reduction, double-helical gearing. New electrically-driven compressor sets have been installed as follows: Two sets of 3,000 cub. ft. capacity each driven by 605 brake horse-power, 3,300-volt three-phase motors, and four sets of 1,500 cub. ft. capacity driven by 300 brake horse-power, 440-volt direct-current motors. These various sets are now distributed in four compressor houses situated near the slipways and fitting-out basin, as shown in Fig. 1. Of the old gas plant two producers are being transferred to a point near the furnaces in the platers' shop, which will be supplied with hot unwashed gas direct. In connection with the working of the old gas plant it may be mentioned that one of the difficulties experienced has been the disposal of the thick tar recovered from the washing plant. This was finally utilised by burning with a patented burner in a boiler which supplied steam for the producer blowers and for saturating the producer blast.

The new turbine power station is a good example of a modern power plant, and has been planned with much care to avoid complexity and facilitate working. It contains a 3,000-kw., 3,300-volt, 50-period three-phase Willans-Siemens set running at 3,000 r.p.m. The steam pressure is 160 lb. per square inch, the superheat to 700 deg. F. and the vacuum 28·5 in. with cooling water at 60 deg. F. There is also a 2,000-kw. Westinghouse three-phase set running at

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Fig. 18.

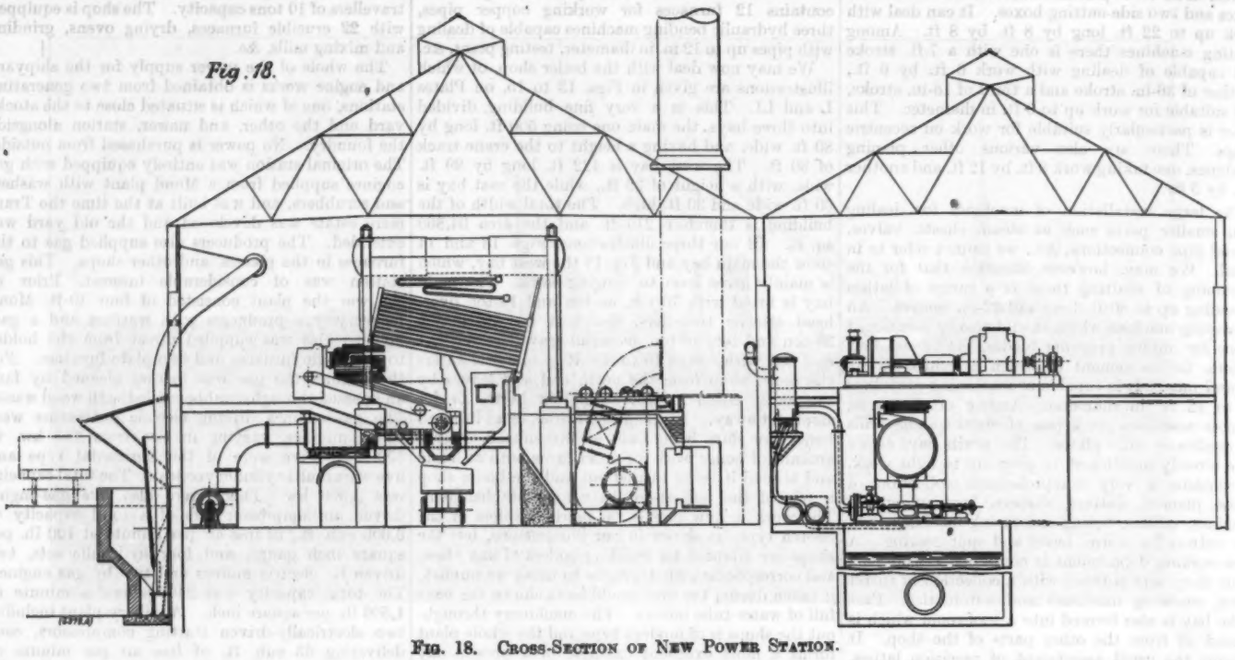


FIG. 18. CROSS-SECTION OF NEW POWER STATION.

3,000 r.p.m., with superheat of 550 deg. F., and the vacuum as above, and a Westinghouse 1,000-kw. direct-coupled direct-current radial commutator set, running at 240 r.p.m., and generating at 440 volts. The generator consists of two machines in tandem. The station also contains a 1,000-kw. rotary converter. There are two Babcock and Wilcox boilers, of 5,380 sq. ft. heating surface. They are fitted with Bennis forced draught chain-grate stokers, of 96 sq. ft. grate area. Both forced and induced-draught fans are fitted. Each boiler has a superheater of 1,864 sq. ft. and there are two economisers of 160 tubes. The coal and ash handling arrangements are of interest, and are well shown in Fig. 18, which is a cross-sectional view of the station. The boiler plant is of course relatively small compared with many power stations and no very elaborate coal and ash-handling appliances would have been justified. As will be seen from our figure, however, with no great expenditure a very efficient and labour-saving arrangement has been obtained. Low-level bunkers are filled by tipping direct from the wagon and from these bunkers the coal is fed by Bennis elevators to overhead bins. There is one elevator to each boiler. The firing floor is set 15 ft. above the basement and clinker is dumped direct into sheet-iron lined wagons in the basement and quenched by salt water sprays fed direct from the general salt water system of the works. The clinker, after the loading of the wagon, is, of course, at once ready for hauling away to the spoil bank or elsewhere without any handling. The station also contains three Lancashire boilers, 30 ft. by 9 ft. and two 30 ft. by 8 ft. 6 in. These boilers are fitted with Bennis sprinkler stokers, and a set of economisers of 480 tubes. Boiler feed is by Weir turbo-pumps, with a Weir reciprocating pump as a standby. The feed is measured by Lea recorders. A view of the turbine room is given in Fig. 19, on the present page.

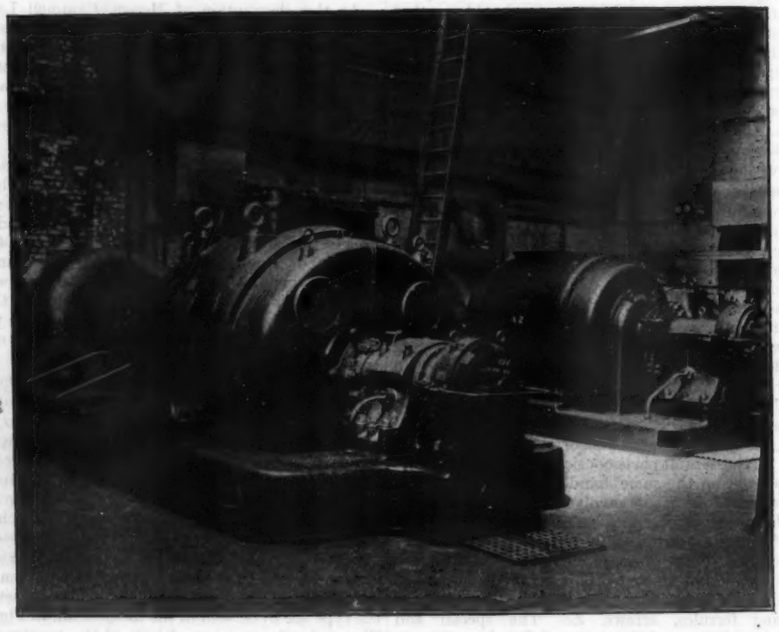


FIG. 19. VIEW IN TURBINE ROOM.

The only other features of this interesting works to which we are now able to refer are the various arrangements in connection with the distribution of power throughout the yard and shops. The electric supply arrangements will be fairly obvious from what we have already said about the power stations. Generation is both at 3,300-volts three-phase and 440-volts direct current. Much of the high-tension energy is transformed to direct current by the rotary converters at the power stations, but in several cases the three-phase current is used direct by motors. This applies for instance to some of the air-compressor units to which we have already referred. The new pumps for emptying the older graving docks are also driven by similar motors, as is a motor-generator set which has been installed for electric welding. This is of 100-kw. capacity and consist of a 150 brake horse-power, 3,300-volt three-phase induction motor coupled to a 110-volt compound wound direct-current generator. It is situated in a special electric welding shop which has been arranged in one of the machine shops in the north part of the yard.

The compressed-air mains are carried to almost every shop and slipway in the works. The mains are as far as possible fixed on the sides of buildings, and where they have had to be run in the ground are arranged in brick culverts, with cover plates to allow of easy access. Local service to ships under construction on slipways is from standpipes and 1 in. diameter flexibles to small portable receivers, each with connections for from six to eight ½-in. hoses. A similar arrangement is used for ships fitting-out in the wet basin, except that the supply is taken on board by 2 in. diameter flexible pipes from bunches of 2-in. cocks arranged in recesses in the quay walls. Great improvement in reducing leakage at flexible connections has been made by adopting a union with an enlarged knurled portion which can be tightened by hand without using any tool. The union contains a leather washer which is secured automatically against loss when a connection is being changed.

The hydraulic arrangements we need not refer to

in detail. The pumping plant is concentrated in the old power station, and the mains are run to the various shops or about the yard as required. Hydraulic mains are carried the full length of all the slipways. In addition to these various distribution systems there is a complete salt-water service throughout the works. This has been installed owing to the fact that no fresh water supply is available other than from the town mains at a somewhat high price. Fresh water is, in general, used only for domestic purposes, and boiler feeding. All cooling work, testing, flushing and other such service is connected to the salt-water supply. The salt-water service is drawn from the wet basin by four electrically-driven centrifugal pumps, each delivering 600 gallons a minute at 60 lb. per square inch, and installed in two pump-houses, one at the head of No. 6 graving dock and the other on the wharf close to the 150-ton crane.

THE INSTITUTION OF GAS ENGINEERS.

(*Concluded from page* 788.)

THE proceedings of the third and concluding day of the annual meeting were opened on June 3, by the despatch of a loyal birthday message to the King, to which a gracious reply was subsequently received.

A symposium on "Carbonisation," prepared, on the invitation of the Institution, by the Society of British Gas Industries, was presented in abstract by Mr. Samuel Cutler, Junr., chairman of the Society's Council. It consisted of a brochure of some 60 pages, accompanied by 33 plates, describing the constructional features of various systems of carbonisation by horizontal retorts, inclined chambers, intermittent verticals, semi-continuous verticals, continuous-intermittent verticals, and continuous verticals. Charging and discharging machinery were also dealt with. In the discussion, Dr. R. Lessing referred to the Riter-Conley system, adopted in America, in which the settings were not of the usual arched type, but set up by silica shapes, 16 retorts being incorporated in one setting. Mr. W. G. S. Cranmer spoke of his experience with the Congdon standpipe; his idea had been to do away with all ironwork on the top of the retort bench, make the pipe a descension pipe, and get the gas in a duct at the stage floor, but it was not entirely successful. Mr. F. W. J. Belton said he had made some calculations with regard to the amount of heat that had been available in the waste gases, as a result of which he had installed a Bonecourt boiler. It had been at work for about two months and had given an evaporation at 100 lb. pressure of 500 lb. of steam per hour, twice as much as was required for the steaming of the retorts. Mr. T. Goulden commented on the absence of any reference in the paper to the De Brouwer system, which was very effective in its working. As to vertical retorts they were most useful, and he could not help feeling that gas engineers must be driven to them for two reasons—the absence of nuisance, and labour saving. Mr. W. M. Valon, Dr. Parker and Mr. J. H. Canning spoke on the question of waste-heat boilers. The latter had been rather surprised on taking the temperature at the base of the stack on the horizontal settings at all periods to find that the waste gases seldom reached the temperature of boiling water; it would seem that the possibility of raising steam by the waste heat depended upon the allowing of a certain amount of heat to pass to waste. Dr. E. W. Smith said at Birmingham Mr. J. Foster had four boilers working on waste gases of temperatures between 600 deg. and 700 deg. C., which evaporated from 8,000 lb. to 10,000 lb. per hour, giving all the steam necessary for normal steaming.

The next paper was on "Oxygen in Gas Production," by Mr. H. J. Hodsman, M.B.E., M.Sc., F.I.C., lecturer on Gas Chemistry in the University of Leeds, and Professor J. W. Cobb, C.B.E., B.Sc., F.I.C. It was summarised by Professor Cobb, and consisted of an examination of a method of generating the heat for carbonisation by the use of a regulated supply of oxygen. Assuming for the moment that oxygen was available in practice for the purpose, it was clear that certain difficulties in the way of continuous gasification of the coke residue by the combination of the well-known reactions, did not arise. Furthermore, when blown with a mixture of oxygen and steam, the coke would be converted into gas with a small expenditure of heat, while the sensible heat of the water gas could be used for carbonising the coal. The complete gasification of coal might then be attained with maximum thermal efficiency. The commercial feasibility of the method depended upon the cost of oxygen, and there were grounds for believing that such cost would not eventually be an obstacle in gasmaking processes. In comparing the process with the normal carbonisation and gasification practice using air, it must be remembered that, apart from the saving of fuel, the cost of the plant for carbonising should be greatly reduced both absolutely and relatively to the tonnage of coal treated; for the speed of carbonisation by internal heat should exceed that of normal practice. In the discussion the president pointed out, in regard to efficiency, there was no doubt whatever that a plant for total gasification of coal could be worked quite easily with oxygen and steam at an efficiency of at least 90 per cent.; 90 per cent. of the whole heat of the coal could be obtained in the form of gas delivered by the apparatus. He also referred to the production of helium and thorium, and considered that gas engineers should seriously study the suggestions put forward in the paper, which he thought was quite an epoch-making one. Other speakers in the discussion—Mr. T. Goulden, Mr. J. P. Leather, Mr. Thomas Glover, and Mr. J. H. Pye, dwelt on the question of the present prohibitive cost of production of the oxygen; Dr. Lessing alluded to the function of the steam in sweeping out the retort; and Mr. W. Townsend asked whether the authors had considered the possibility of making the oxygen gas on a large scale and distributing it to those gas works requiring it; if that were possible a good many objections would be removed. Professor Cobb, in his reply, said he had no intention whatever of attempting to give figures of the capital expenditure necessary. So far as one could see, the cost of production of oxygen was going to be very much lessened as the scale of operation increased, and that all tended towards the establishment of central plants of considerable size for the supply of oxygen.

Mr. Godfrey Warburton, F.C.S., of Tottenham, then read a paper entitled "Contemplations on the Report of the Fuel Research Board." Notwithstanding the apparent freedom allowed gas undertakings in being able to choose what standard number of British thermal units should be adopted for the gas to be supplied, the author stated that the crucial factor appeared to be the limitation of inert constituents to 15 per cent. The report did not give any indication as to what constituted inerts. Did the Board consider that oxygen and nitrogen in the proportions to form air were inert constituents? All combustible constituents were inert without oxygen, either by itself or mixed with nitrogen, as air. Oxygen, or air, in the presence of combustible constituents was anything but inert. As it had been the practice for many years amongst the majority of gas undertakings to add air to assist purification, the importance of these considerations became manifest. The Board saw clearly the inadvisability of fixing one standard of British thermal units for the whole of the country. Then why did they not follow the same principle with regard to inerts? In one district it might be advisable to limit inerts; in another no benefit would accrue thereby. As the consumer was only to be charged for the actual British thermal units received, and the gas undertaking had to adjust his appliances free of charge to suit the gas supplied, his protection appeared ample. The president in opening the discussion thoroughly agreed with the author that inerts must be divided into true inerts, and those which were not inerts. Referring to the Gas Regulation Bill (which embodied the recommendations of the report), it would be noticed that undertakings were left in the hands of the Board of Trade to a certain extent, but the Board need not impose any limits on the inerts at all. He hoped to get the wording more fair to the gas industry before the Bill was finally passed. Mr. Leather and Mr. J. Ferguson Bell (Derby) spoke on considerations involved in the question of the limitation of inerts; Mr. G. M. Gill, and Mr. W. J. Smith were in favour of a low figure for inerts; Mr. A. E. Broadberry expressed the opinion that the real economical figure, below which it would be sacrificing the consumer to endeavour to work, depended upon the local conditions. Mr. Warburton, in replying, pointed out that air had been proved by the work of the Institution's Gas Investigation Committee to be anything but an inert, and the president had stated that carbon dioxide was very useful when added to certain gases in gas engine practice. If certain qualities of gas of certain compositions could be definitely assigned to certain operations, the question of inerts might be got rid of altogether.

Owing to shortness of time the remaining paper on the programme, had to be taken as read. It was by Mr. Joseph Fisher, Assoc.M.Inst.C.E., of Tottenham, on "Electricity Supply by Gas Companies," and gave a description and results of working of the Wood Green electricity plant of the Tottenham District Light, Heat and Power Company. The electric generators were driven by vertical high-speed gas engines, made by Messrs. E. S. Hindley and Sons. There were two sets—one of 100 kw.; and one of 200 kw.; another of 200 kw. was now being installed. There was a battery of 270 cells capable of 840 ampere-hours at 480 volts. The supply was by a continuous current on three-wire system at 240 volts and 480 volts. The capital cost of the undertaking to December, 1919, was 33,380*l*. The charges for current were for lighting and all domestic purposes, 7*d*. per unit for the first 100 units and 6½*d*. per unit for all over that. For power the scale varied from 4*d*. per unit for the first 100 units to 3*d*. for all over 400 units. The author discussed lighting and power efficiency, fuel efficiency, the load curve and, finally, the essential feature of the whole scheme, viz., the gas engine, as to which he considered there was room for great improvement. Water circulation and exhaust gases were a great loss of available and valuable heat; and this heat was in a much more tractable form than the latent heat of steam. Means should be found for utilising it; and the "Still" engine seemed to be a step in the right direction for a solution of this problem.

The respective presidents of the Société Technique de l'Industrie du Gaz en France, the American Gas Association, and the Associazione Italiana della Industrie Gas e Aqua, were elected honorary members of the Institution. Earlier in the proceedings, it was announced that Mr. Thomas Goulden, chief engineer to the Gas Light and Coke Company had been elected president, in succession to Sir Dugald Clerk; and Mr. J. D. Smith, of Belfast, as junior vice-president; Mr. T. Hardie, of Newcastle-on-Tyne, succeeded to the senior vice-presidentship. The election of 46 candidates to membership was also announced, and it was resolved to hold the annual meeting next year in London. The proceedings terminated with votes of thanks to the president, council, and all who had assisted in the work of the Institution during the past year; these were heartily accorded, as was also a vote of thanks to the Institution of Mechanical Engineers for their kindness in granting the use of their building for the purposes of the meeting.

"THE SENTINEL WORKS MAGAZINE."—We have received a copy of this new publication for June, which is issued by the "Sentinel" Wagon Works (1920), Limited, Shrewsbury, and gives information which appeals more especially to the members of the company's staff.

THE "DEUTSCHE BETON VEREIN" (CONCRETE ASSOCIATION).—The annual meeting of the German Beton Verein, held at Berlin in May last, was very well attended. The report presented mentioned negotiations with the Norddeutsche Lloyd concerning rules as to the construction of ferro-concrete boats, and preserving concrete and ferro-concrete on moorings. The general committee comprises also representatives of the artificial stone industry. Among the papers read was one by E. Probst, of the testing station for building materials at Karlsruhe, on new methods of testing with special regard to the need of economizing in cement and building materials. As regards the preservation of hydraulic cements in sea water, experiments have been going on for 15 years on the island of Sylt, and Professor Gary, reporting to the Government, arrives at the conclusion that the cement used should be very rich in silica, but poor in alumina and iron oxide. When much lime is present, the addition of trass may be advisable. The chief point, however, is that the cement should be dense and impermeable to sea water; for this purpose it should externally be hardened in hot and moist air before being exposed to the action of the sea water. Concrete, the mortar of which contains much sand, is not considered sufficiently dense for use in sea-water.

ELEKTRON-METAL (MAGNESIUM ALLOY).—The Elektron alloys of the Chemische Fabrik Griesheim-Elektron are alloys of about 80 per cent. of magnesium with zinc and other metals; they resemble aluminium in appearance and properties, but are substantially lighter even than aluminium, the specific gravity being about 1·8. The tensile strength ranging between 12 kg. and 15 kg. per square millimetre, the elongation and contraction of area amounting to 3 per cent. or 4 per cent., and the hardness being 10 deg. or 15 deg. by the Shore test, the alloy has found extensive use for the casting of artificial limbs, casings, parts of motors, piano frames, &c. Certain precautions have, however, to be observed in melting and casting the alloy, which processes Felix Thomas describes in *Stahl und Eisen* of February 26 last. The alloy is generally supplied in lumps of 2 kg. weight and melted in steel crucibles of not more than 13 litres capacity. The alloy melts near 630 deg. C. and should not be superheated, except when the articles are very thin-walled, lest the melt catch fire. Such fires, which are not dangerous, can be suppressed by dropping calcium alloy on the burning metal; the calcium makes the alloy brittle, however, and other materials would spoil it. Magnesium combines with both oxygen and nitrogen, and the overheated alloy becomes hence contaminated with oxide and nitride; in the presence of moisture, on the other hand, hydrogen would be liberated, causing explosion and the formation of blow holes in the metal. The moulds are made of thoroughly dry sand and are preheated or used as they come from the drying stove, in which they are heated up to 400 deg. C. Loose sand particles should carefully be avoided, as silicon-magnesium might be formed rendering the alloy brittle like the oxide. The moulds and cores may be coated with graphite before drying. The cast article is cut with the saw, cleaned with a steel brush, and may be etched with nitric acid (free of chlorine) if it should have turned grey in moist air. Elektron can be soldered and be given different colours by the aid of mordants.

SIX-CYLINDER 90-B.H.P. PARAFFIN MARINE MOTOR.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

Fig. 1.

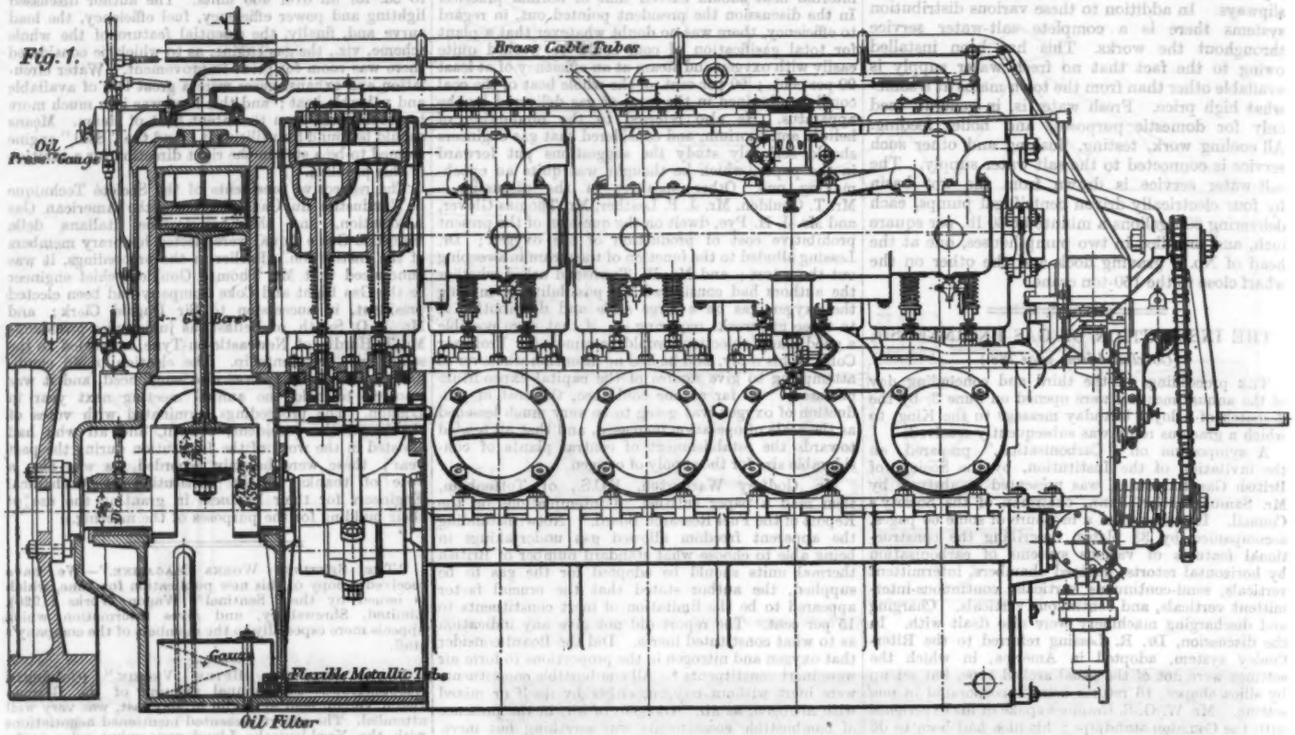


Fig. 2.

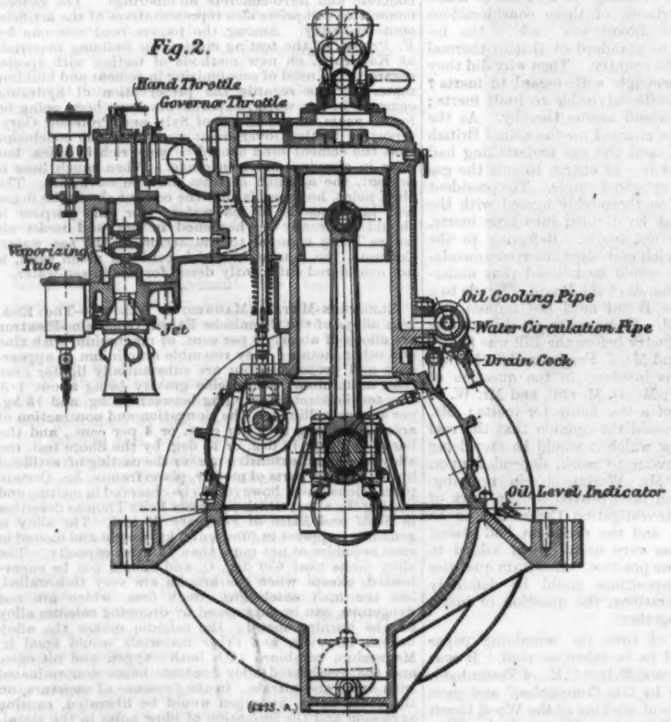
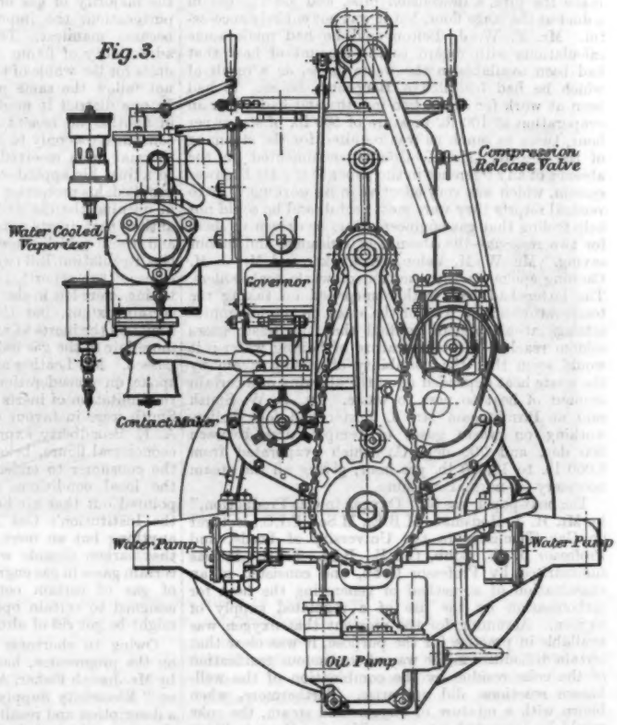


Fig. 3.

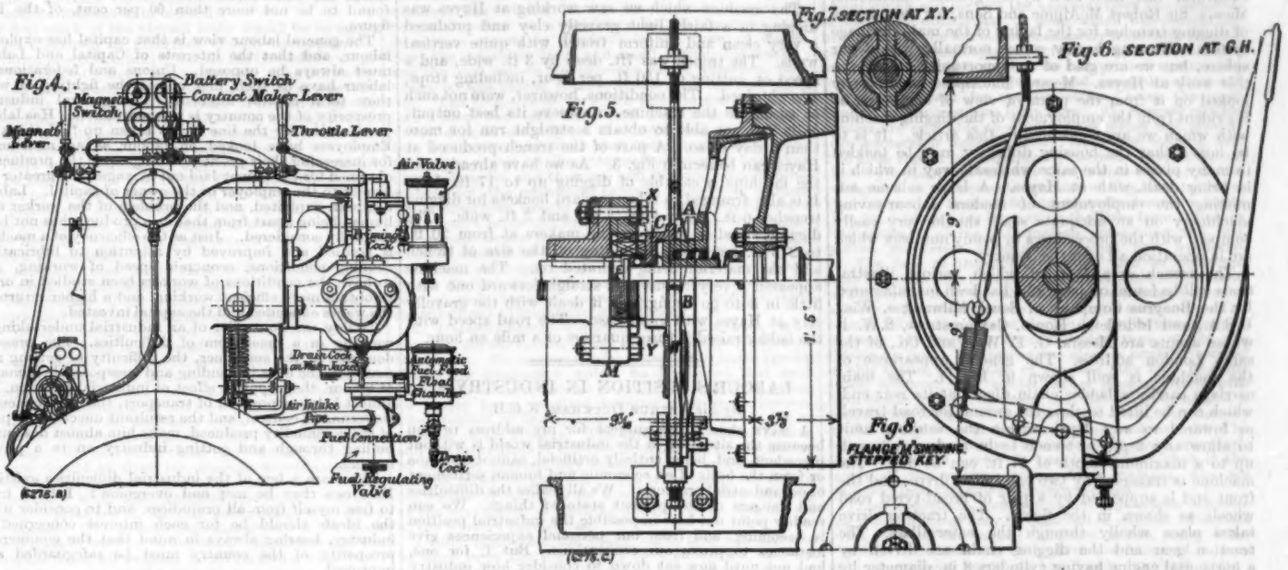


THE illustrations on this and the opposite pages show the general arrangement and details of some of the latest types of marine motors for paraffin or petrol constructed by the Parsons Motor Company, Limited, of Town Quay, Southampton. These motors are thoroughly standardized in design, interchangeability of similar parts having been secured not only in respect of each engine, but as far as possible throughout the whole range of engines. Two-cylinder sizes only are employed, and with each size a series of engines is built containing a number of cylinders varying according to the power desired. The smaller series of engines has cylinders of 4½ in. bore by 6 in. stroke, and covers a range of power from a single-cylinder 7 brake horse-power engine to a six-cylinder 42 brake horse-power engine, the speed in all cases being 800 r.p.m. to 950 r.p.m. for this series. The larger series has cylinders 6½ in. bore by 8 in. stroke, the power ranging from 30 brake horse-power to 90 brake horse-power, at 600 r.p.m. to 700 r.p.m. These powers are obtained on petrol, the rating being slightly less when paraffin is used as fuel.

Figs. 1 to 3, on this page, show the design of the largest engine of the latter series, namely a six-cylinder model of 6½ in. bore by 8 in. stroke, rated at 90 brake horse-power. As in all the Parsons engines, the cylinders are cast separately, and are tested to 400 lb.

THE PARSONS PARAFFIN MARINE MOTOR.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.



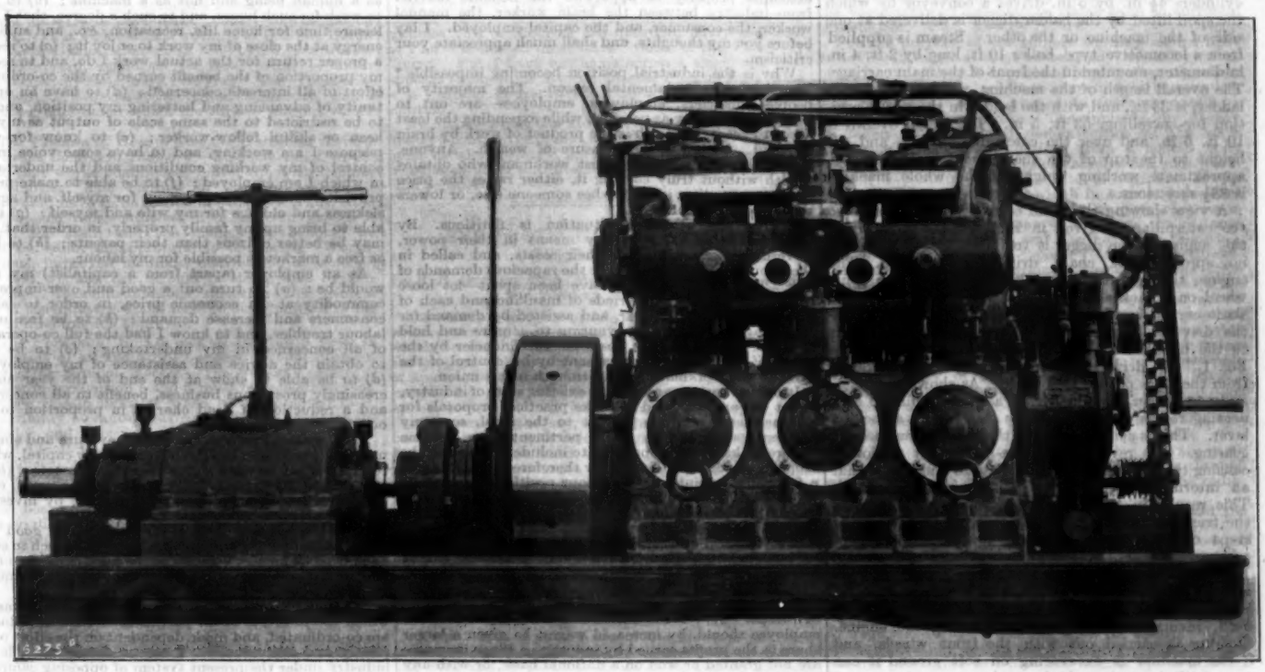


FIG. 9.

per square inch internally, the water jackets being also tested to 50 lb. per square inch, thus meeting the requirements of the Board of Trade and Lloyd's Register. The crankshafts of all engines also conform to the requirements of these authorities. Most of the details of construction will be clear from the illustrations, but it may be noted that the crankshaft bearings are held in the lower half of the crank-case, the caps being on top of the shaft instead of beneath as is usual in motor-car practice. In a marine engine which is inaccessible from the underside, there is obviously no reason for adopting the less mechanical practice which is more convenient in the case of motor vehicles. Circular doors in the upper part of each crank-case on both sides of the engine render inspection easy, and permit of the removal of any piston and rod without dismantling the cylinder. The exhaust from each set of three cylinders passes through its own water-cooled silencer, and, as usual, the vapouriser for paraffin fuel is located in this silencer. The whole of the vaporiser may be withdrawn with ease by undoing a few nuts on the underside of the exhaust branch. The crankshaft is made from a single steel forging with bearings between every crank. It is drilled for lubrication and is flanged for carrying the flywheel. All crankshaft bearings have bronze shells filled with white metal, and a similar construction is used for the big ends of the connecting rods.

Fig. 4, on this page, shows the arrangement of the carburettor and fuel admission devices, as well as of the controlling levers for the operation of the engine. The clutch used on the Parsons engines is illustrated in Figs. 5 to 8. Bolted to the outside end of the flywheel rim is a metal cone, with the internal face of which a corresponding cone which slides on the shaft, engages. A spring normally holds the coned faces in frictional contact, but they can be forced apart by a pair of forked pieces operated by the lever shown in Fig. 6. These forks, marked A and B in Fig. 5 are each thickened at one point, and the action of the lever is to bring the thickened parts opposite each other, thus forcing the sliding cone away from the fixed abutment C. The reversing gear employed is particularly simple, being somewhat on the lines of the headstock of a lathe in so far as there is a back-gear shaft which is stationary during the ahead drive. It contains no friction clutches, small pinions or epicyclic gears. The external appearance of it is shown in Fig. 9, which represents a three-cylinder 45 brake horse-power marine type engine, complete with clutch and reversing gear. As this engine is virtually half of the 90 brake horse-power engine illustrated in the earlier figures, a good idea of the appearance of the larger engine will be obtained from the photograph.

EXCAVATOR FOR TRENCH DIGGING.

In connection with a large housing scheme being carried out at Hayes, Middlesex, an interesting trench excavator has been used by the general contractors, Messrs. Sir Robert McAlpine and Sons, for the purpose of digging trenches for the laying of the main drainage system. Housing hardly comes normally within our sphere, but we are glad of an opportunity to refer to this work at Hayes. Messrs. MacAlpine have clearly looked on it from the point of view of engineers, as is evident from the employment of the digging machine with which we are concerned in this article. It is to be hoped that the housing difficulty may be tackled in many places in the same wholesale way in which it is being dealt with at Hayes. A large scheme admitting the employment of modern labour-saving machinery on an adequate scale should very easily compete with the proceedings in penny numbers which are in operation all over the country.

The trench excavator, of which various illustrations will be found on page 828, has been manufactured by the Bucyrus Company of South Milwaukee, Wis., U.S.A., and Iddesleigh House, Caxton-street, S.W. 1, whose agents are Messrs. G. F. West and Co., of the same London address. The general appearance of the machine is well shown in Fig. 1. The main carriage carries a ladder chain digger at its rear end, which can be lifted to clear the ground for road travel, or lowered to any depth within the working limit to allow any depth of trench to be made. A trench up to a maximum depth of 17 ft. can be dug. The machine is traversed by two caterpillar drives and the front end is supported by a pair of broad-tyred road wheels as shown in the figure. The traction drive takes place wholly through the caterpillars. The traction gear and the digging chain are driven by a horizontal engine having cylinders 8 in. diameter by 12 in. stroke. A second independent engine having cylinders 4½ in. by 5 in. drives a conveyor by which the spoil lifted by the ladder digger is delivered at one side of the machine or the other. Steam is supplied from a locomotive type boiler 10 ft. long by 2 ft. 4 in. in diameter, mounted in the front of the main carriage. The overall length of the machine, without the digger ladder, is 33 ft., and with the ladder in the raised position for travelling, 53 ft. 5 in. The width overall is 10 ft. 6 in. and over the caterpillars 10 ft., and the height to the top of the shelter roof is 15 ft. The approximate working weight of the whole machine is 38½ short tons.

A view showing the main engine and the drive to the caterpillars is given in Fig. 2. The drive from this engine to the digger is very direct and there are no sprockets or chain drives incorporated. The engine, through straight gearing drives a large spur-wheel on a jack shaft as show in Fig. 2. This jack shaft carries crank discs at its ends, and from these the drive is taken by built-up side connecting-rods to the bucket-chain shaft, as quite clearly shown in Fig. 1. The drive to the travelling gear is also taken from the discs on the jack shaft. As shown in Fig. 1, and to a larger scale in Fig. 2, a second built-up connecting rod is carried from the disc pin to a rocking lever. This is connected up to the caterpillars through gearing. The revolution of the jack shaft obviously causing the rocking lever to oscillate to and fro, so that an intermittent travel of the machine is obtained. This results in the chain buckets being fed against the trench face which they are cutting in a series of steps or bites. The rocking lever does not, of course, traverse the machine on its back stroke. It drives through a ratchet arrangement, so that a travel in one direction, but in a series of steps, is obtained. For road travel a direct gear drive is used, reversing being got by reversing the engine. Steering is carried out with the front wheels, and if the machine is excavating on soft ground it can very easily be run on planks or sleepers.

The buckets of the digger chain are of the open or scraper type, consisting essentially of flat plates with cutting teeth on one edge. They are connected to the chain by means of pivoted steel arms. The buckets drag along the face which is being cut, and the spoil piles on the top of them. At the top of the chain as the buckets pass round the upper tumbler to begin their return journey, the spoil falls off on to a cross belt-conveyor which forms part of the machine. The motion of the bucket round the tumbler is such that even sticky and adherent material is easily thrown off and is not carried forward by the bucket to fall back into the trench. The cross belt-conveyor delivers the spoil at either side of the excavation, depending upon which way it is running. As we have said, it is driven by a separate engine from the chain digger, and the direction of motion of the conveyor is reversed by reversing the engine. The distance to which the spoil is thrown on either side of the machine is controlled by controlling the speed of the conveyor engine. It may be dumped close alongside the trench if it is required for refilling, or may be thrown to some distance. An extension to the conveyor may be fitted, if desired, and used for moving the spoil still further away, or for loading dump cars. This extension conveyor is shown in process of adjustment in Fig. 3.

The machine which we saw working at Hayes was digging in a fairly light gravelly clay and produced a very clean and uniform trench with quite vertical walls. The trench was 7ft. deep by 3 ft. wide, and a speed of cutting of 150 ft. per hour, including stops, was obtained. The conditions, however, were not such as to enable the machine to achieve its best output, as it was not able to obtain a straight run for more than a day or so. A part of the trench produced at Hayes can be seen in Fig. 3. As we have already said the machine is capable of digging up to 17 ft. deep. It is also arranged to take standard buckets for digging trenches 6 ft., 5 ft., 4 ft., 3 ft., and 2 ft. wide. The digging speed is given by the makers at from 20 ft. to 275 ft. per hour, depending on the size of trench and the material being operated on. The machine appeared a very robust and straightforward one with little in it to go wrong, and it dealt with the gravelly clay at Hayes with great ease. The road speed with the ladder raised is three-quarters of a mile an hour.

LABOUR'S POSITION IN INDUSTRY.*

By Sir ARTHUR DUCKHAM, K.C.B.

I HAVE chosen this subject for my address to you because the situation in the industrial world is without precedent, and, being entirely artificial, cannot continue or form the basis of an economic and human settlement of our industrial problems. We all realise the difficulties and dangers of the present state of things. We can readily point out how impossible the industrial position is becoming, and from our personal experiences give instances to prove our contentions. But I, for one, had not until now sat down to consider how industry can be put on a proper basis—that is, a basis which attempts properly to apportion the benefits derived from industry between the brain worker, the manual worker, the consumer, and the capital employed. I lay before you my thoughts, and shall much appreciate your criticism.

Why is the industrial position becoming impossible? There is one fundamental reason. The majority of people—financiers, employers, employees—are out to get as much money as possible, while expending the least effort to get it. Wealth is the product of work by brain or hand. Money is the measure of wealth. Anyone, from millionaire to the poorest workman, who obtains wealth without truly earning it, either raises the price of the commodity, impoverishes someone else, or lowers the value of the currency.

To-day the economic situation is fictitious. By taxation, by loans, by every means in their power, Governments have realised their assets, and called in their countries' wealth to meet the rapacious demands of war. These colossal sums have been spent—let loose as it were among the myriads of mankind and each of us, according to his power, and assisted by demand far exceeding supply, is endeavouring to acquire and hold as much of the booty as possible—the financier by the power of his money, the merchant by his control of the market, the workman by the strength of his union.

In endeavouring to realise the existing state of industry, to set out an ideal, and to make practical proposals for advancement from the present to the ideal, so many problems arise and so many pertinent facts become apparent that it is not possible to include them all in the scope of an address. I can only therefore put before you a few salient points on the labour position in industry. What briefly are our specific difficulties in industry to-day? Colloquially, "We don't know where we are." Higher wage demands were first based on the increased cost of living; but now many other reasons are advanced for claiming higher rates of pay. The miners are asking for an advance in wages because the price of coal has been increased. The railwaymen give as a reason for their demands that the dockers have obtained a flat-rate of 16*s.* per day. Trade unions in general claim that the employee should, by increased wages, be given a larger share in the profits earned by industry. Wage increases are not granted or won on a national basis, or with any consideration of the general industrial position of the other workers, but sectionally, district by district, union by union. The building operatives in the Liverpool area force a local advance of 4*d.* an hour (2*s.* to 2*s.* 4*d.*). Immediately a demand is made in other large towns for 3*s.* Men will not work in Manchester at 2*s.* while wages for similar work in Liverpool are 2*s.* 4*d.* Labourers in one industrial section are earning more than the mechanics in another industrial section; and yet both may be employed in the same works or on the same job.

Similarly, the hours of work for differing classes of men may vary on the same job—44 hours for bricklayers, 47 hours for engineers. Some may work overtime; others not. Some overtime is paid for at 1¼ ordinary time; some at 1½.

Working hours have been properly decreased. Higher wages have been properly paid to meet the higher cost of living; but the chief argument of the Labour Party, that shorter hours would mean a higher output per hour, has been entirely refuted. The output per man per hour, instead of increasing, has decreased amazingly, even though the time curtailed has usually been those unproductive pre-breakfast hours. I was able to make a fair comparison in output between 1914 and 1919; and I found that the output per man-hour in 1919 was about 70 per cent. of the 1914 figure. I believe to-day that things are still worse, and that the output would be found to be not more than 60 per cent. of the 1914 figure.

The general labour view is that capital has exploited labour, and that the interests of Capital and Labour must always be opposed. Unions and federations of labour have as their first object the fighting of what they term capital interests. The general industrial prosperity of the country is not considered. Has labour justification for the line it has taken up? I think so. Employers have looked on labour as an instrument for increasing their profits. The greater the production obtained for the money laid out in wages, the greater the benefit to the employer or the owner of capital. Labour has been exploited, and the problem of the worker as a human being apart from that as a producer has not been generally considered. Just as the efficiency of a machine is studied and improved by attention to lubrication, running conditions, economic speed of working, &c., so have the conditions of workers been studied in order to obtain more efficient working, and a higher return on the wages expended and the capital invested.

To-day the Controller of an industrial undertaking is working in a maelstrom of difficulties. The pressing demands of the consumer, the difficulty of getting raw material, the ever impending and irresponsible demands of labour, the crippling effect of industrial taxation, the almost helpless position of transport, the irksomeness of Government control, and the resultant uneconomic price of the commodity produced, make him almost despair of pulling through and getting industry on to a proper footing.

These are a few of the industrial difficulties existing. How can they be met and overcome? I have tried to free myself from all prejudices, and to consider what the ideals should be for each interest concerned in industry, bearing always in mind that the commercial prosperity of the country must be safeguarded and improved.

As a worker, my ideal would be: (*a*) To be treated as a human being and not as a machine; (*b*) to have to work for such hours, and to such a degree, that I have leisure time for home life, recreation, &c., and sufficient energy at the close of my work to enjoy it; (*c*) to receive a proper return for the actual work I do, and to receive my proportion of the benefit earned by the co-ordinated effort of all interests concerned; (*d*) to have an opportunity of advancing and bettering my position, and not to be restricted to the same scale of output as my less keen or skilful fellow-worker; (*e*) to know for what purpose I am working, and to have some voice in the control of my working conditions and the undertaking in which I am employed; (*f*) to be able to make proper provision against unemployment for myself, and against sickness and old age for my wife and myself; (*g*) to be able to bring up my family properly, in order that they may be better citizens than their parents; (*h*) to have as free a market as possible for my labour.

As an employer (apart from a capitalist) my ideal would be: (*a*) To turn out a good and ever-improving commodity at an economic price, in order to satisfy consumers and increase demand; (*b*) to be free of all labour troubles, and to know I had the full co-operation of all concerned in my undertaking; (*c*) to be able to obtain the advice and assistance of my employees; (*d*) to be able to show at the end of the year an increasingly prosperous business, benefit to all concerned, and a reduction of dead charges in proportion to the output.

As a capitalist or provider of money pure and simple, my ideal would be: (*a*) To ensure that my capital, which represents my savings out of earnings, is safe; (*b*) to ensure that I am receiving a proper return on it, commensurate to any risk I may be running by investing it in industry.

After formulating these ideals I felt "real good" as the Americans say; and it was a horrible wrench to come back from an idealist's dream to the hard facts of to-day, and to try and indicate some of the steps which might be taken to reach these ideals.

The fundamental need is to arrive at some scheme by which the interests of all parties concerned in industry are co-ordinated, and made dependent on the effort of all jointly and individually. I see no future possible for industry under the present system of opposing camps of workers' unions and employers' federations, recruited and disciplined for the sole purpose of fighting each other for the wealth created by industry, with the Government standing by as an arbiter ready to step in when it becomes apparent that the general well-being of the State is endangered—the action of the Government taking the form of some palliative or expedient to stop the process of annihilation temporarily. I see no sound future for industry founded on the proposals of the trade unions and socialists. Nationalisation, syndicalism, guild socialism, all are open to one fundamental objection. Human nature must be changed before such schemes can prove successful. Unselfishness will have to be the attribute of the many, instead of the eccentricity of the few.

I believe Home Rule for industry is the only solution Industry must control industry. The basis of any successful scheme must be that the self-interest of each participator must be harnessed, and made to play a part in securing success for the whole. I put forward the following as a brief outline of the steps which might be taken to achieve this end.

The Government should call a council of representatives of employers' federations and workers' unions. This council should first be asked to accept the principle

* Presidential Address read before the Society of British Gas Industries, at their annual meeting at Sheffield, June 15, 1920.

of setting-up a Parliament of Industry, composed of the duly elected representatives of the various interests. The principle being approved, the next step would be to agree as to the size, method of election, &c., of the new body. The work of the first council would then be concluded, and the Government would cause the first Industrial Parliament to be elected.

The first work of the elected body would be to agree how the chairman or chairmen should be appointed, to lay down procedure, and to decide the immediate scope of the Parliament's work and authority. The authority of the Industrial Parliament should be as wide as possible, provided the well-being of the State is not endangered, and provided the liberty of the individual is safeguarded. To obtain a truly representative body, all workers and all employers must be brought within the fold of unions of workers or federations of employers, and the ballot must be secret. The size of the Industrial Parliament must not be unwieldy, and, though it would be necessary to sit practically continuously in the earlier days, the sittings should later be so arranged as to allow members time to keep in touch with their industry and to follow their own avocations.

The problems that would have to be tackled immediately would include the following :—

A. *The Problem of the Vicious Circle.*—Higher wages are demanded to meet the higher cost of living. Higher wages being granted, the cost of production and the price of commodities is increased. It is generally agreed that wages should increase in proportion to the cost of living. At present the increases are only obtained by industrial pressure and the threat of strikes. My solution of this problem is that all workers should receive a subsistence rate as well as a wage. The subsistence rate should approximate to the cost of providing the necessities of life to a worker and (say) three dependents. This rate should be fixed for areas in accordance with the cost of living in such areas ; and it should vary automatically with the statistical returns of the cost of living—variations in the rate being made, say, every three months. The subsistence rates should be the same for each class of workers in the area. In addition to the subsistence rates, all workers would receive a wage rate ; and this wage rate would vary in accordance with the grade and skill of the worker. All workers of the same class would receive the standard hourly wage rate in whatever industry or part of the country they might be occupied. Thus a blacksmith working in London, Luton or the Land's End, whether in a shipyard, gas works, or builder's yard, would get the same wage per hour ; his subsistence rate only varying. The Industrial Parliament, or a specially appointed committee, would settle the grades under which the various workers would come.

B. *The Problem of How to Give the Workers a Definite Voice in the Control of Industry.*—To solve this I would suggest that works committees be set up, with definite responsibilities. The method of election and other details would have to be settled in each case ; but, from my experience, representatives of the different grades of workers, the staff, and the management should be elected by ballot or appropriately appointed. Works' conditions, improved methods, distribution of benefits, safety and welfare, &c., should be dealt with by this committee. Recommendations affecting the general policy of the industry would have to be submitted to the board of directors for approval.

C. *The Problem of How to give all Interests a Voice in the Direction of an Industrial Concern, Capital Management and the Manual Worker.*—The worker's capital is his power of production ; and it must be recognised that he invests this in industry when he is employed in it. It is certainly advantageous to have the benefit of the knowledge and experience of the actual worker on a board of directors ; and it is right that the worker should have knowledge of how an industry is conducted and a say how it should be run. I therefore suggest that the workmen should have a representative or representatives on the board of directors. The member of staff or workmen directors would have to be settled individually in each industrial unit. They would have to be elected by ballot and approved in general meeting as is the usual practice. Properly-elected works committees, together with staff and workmen directors, would do much to eradicate the feelings of mistrust and suspicion that exist to-day between employers and employees.

D. *The Problem of Dealing with Trade Disputes.*—The main lines on which industry is to be run would be laid down by the Industrial Parliament. The difficulties arising in the various units would be settled by the works committee and boards of directors. But no local ruling which would affect district, sectional, or national policy must be put into force unless it is referred to the local, sectional, or national body as the case may be. The various industrial bodies, local and district, would be built-up on the lines of the Whitley Councils, and existing machinery would be used as far as possible.

E. *How can Benefits be Shared ?*—As already pointed out, the worker would be entitled to receive a subsistence rate, varying with the cost of living in the district in which he works, and a standard wage fixed in accordance with his grade or skill. This wage can and should be augmented by a system of payment by results. Piece-work rates, premium bonuses, tonnage rates, are all methods which suit varying industries ; and the council of an industry should first consider the most suitable methods of rewarding skill and application as applied in a special industry, and then the works committee should be left to select or modify the system, and render it suitable to their individual case. Such benefits would accrue weekly, and would be a definite wage ; the worker always being safeguarded by the standard minimum.

F. *The Problem of How the Benefits earned by the Industry in General over the Yearly or Half-Yearly Period are to be Divided among the Interests Concerned.*—It is not possible to lay down a sound and workable scheme of profit-sharing which is applicable to all and every industry. Conditions vary so widely that only the general lines can be attempted here. The first charge on industry is the weekly or monthly payment to the worker. The worker invests his capital—that is his potential value as a producer in the business—and receives a return or dividend in the form of wages. Next the capitalist, large and small, invests his money ; and the next call on the earnings would, therefore, be a return on this capital commensurate with the risk being run. The proportions in which any surplus remaining (after these two calls have been met) is to be divided would depend entirely on the individual undertaking. But it must be laid down that these benefits are to be paid over direct to the interests concerned, and they must belong to, and their use and division be controlled entirely by, the individual interest. Thus the workers would have their benefit committee, which would receive the moneys after the declaration of bonus or benefits, and would decide for instance whether all the moneys received should be divided among the workers in proportion to the wages earned or whether only part should be so divided and the remainder put to reserve for paying sick benefits, providing extra holiday pay, contributions to their unions, and so on.

G. *Unemployment.*—Unemployment insurance is a necessity for the success of any general scheme of payment by results. No worker can be expected to make special efforts for production unless he feels sure that such efforts will not result in his or his fellow-workers' services no longer being required because of over-production. The problem of unemployment benefit is far too big to consider in an address. The presence of casual labour, and the movement of workers from one works or industry to another, prevent any scheme being localised. Any scheme must be national ; but it certainly should be controlled by industry as a whole. The responsibility of the prevention of shirking should be the special care of the workers themselves.

I fully appreciate the many voids that will have to be filled in in the proposals I have submitted, and the many difficulties that will have to be met and overcome. From my personal experience in industry, however, I am convinced that a scheme somewhat on the lines sketched above is the only solution of our industrial troubles. In considering the question, many problems as I have indicated must arise. Some of them are very thorny ; but I have not come across a single one that appears to me to be insurmountable if on all sides there is a genuine desire to come to a fair and equitable solution.

My main contentions are that industry must be organised to control itself, and that the benefits of industry must be shared fairly among the producers of those benefits so using self-interest as a motive force of industrial prosperity.

EYE PROTECTION IN WELDING OPERATIONS.*

By R. R. BUTLER, B.Sc., Member of the British Acetylene and Welding Association.

THERE is probably no article in the welders' equipment which receives less personal attention, or concerning which he has less exact knowledge of essentials, than the goggles. Various types of this very necessary piece of apparatus are to be found in every welding shop and, judging by daily experience, the majority of welders appear to be content if, on reaching for the goggles, they obtain a structure of, say, aluminium and elastic, carrying two circular pieces of coloured glass. If perchance the goggles are not to hand, and time is pressing, eye protection is dispensed with altogether. It is in the hope that a paper dealing with this subject, both theoretically and practically, will be of general utility, that I venture to read such a paper before this association.

The National Safety Council, Chicago, U.S.A., published in October, 1919, a set of rules for the guidance of welders (whether using acetylene or electricity). There has been to the best of my knowledge, no similar "Safety First" campaign in this country, and certain sections of the Chicago rules dealing with eye protection are given here. "Re acetylene welding : 69. An important hazard in the use of the blowpipe or torch is that of injury to the eyes, by the heat and glare from the work and by particles of hot metal that fly up from the weld. Properly-coloured lenses fitted in goggles will furnish complete protection to the eyes. Workmen sometimes think they do better work without them or are too indifferent to wear them, so the injury is done before it is realised. 70. Amber, yellow and greenish-yellow glasses are the most efficient for protection. The selection of lenses, however, should not be left to the workman, or even a foreman ; goggles with the proper lenses may be procured from several reliable manufacturers. The expensive coloured lenses may be protected from injury from flying sparks by a clear glass lens outside of each coloured lens in the frame."

Somewhat more detailed instructions are given in the section dealing with arc welding. As these have a very definite bearing on our subject to-night, they also will be included here : "89. All the light rays in the spectrum are given off by the welding arc. The infra-red rays which are invisible to the eye produce a sensation of heat. Orange, yellow and green are the illuminating rays, which make objects visible. Blue rays obscure the vision and make objects indistinct. The ultraviolet rays are invisible, and while they cause no immediate discomfort, they are very dangerous. They affect the skin like sunburn, and may cause cataract and even total blindness if looked at with the naked eye. 90. In welding, because of the great intensity of the arc (6,000 deg. F.), it is of the utmost importance to provide lenses which will protect the operator from the injurious effect of the radiations. A glass which will reduce the brightness of the arc is not necessarily a suitable one for protection against injurious infra-red rays. Blue lenses are not satisfactory, as they do not protect against the harmful rays. Amber, yellow and greenish-yellow are the most efficient for eye protection, being the most opaque to the injurious light rays. 91. Several reliable dealers are now able to supply glass which will provide sure protection against injury from the welding arc. The glass should be scientifically correct—that is, should show by a spectrum analysis that it does not permit the passage of an appreciable amount of the harmful rays. The Bureau of Standards has recently issued a paper (No. 93, "Glasses for Protecting the Eyes from Injurious Radiations") giving information concerning the protective properties of various glasses now available. 92. The face of the operator must also be protected from the heat rays ; therefore a shield (held in the hand or supported from the shoulders) or a helmet (worn on head or supported from the shoulders) is necessary. The helmet offers the greater degree of protection since it protects the operator from reflected rays, whilst the shields do not. The protective glass is usually inserted in this shield, or helmet, as the case may be. In some cases, however, the welder wears goggles fitted with light shade protective lenses, and the shield or helmet is fitted with a light shade protective glass, the density of the two glasses giving the required colour. 94. The reflected rays sometimes cause skin-burn of the operator's face or back of neck. It has been found that if the inside of the welding room, draw curtains, &c., are painted black this will be largely avoided."

These constitute such published regulations concerning this subject as may be regarded as official. They are brief, and to the point ; and not unlike many other "official" documents, they skirt the fringe of a great subject, without becoming too deeply involved in it.

I shall endeavour to place before you the results of recent research, in such a way as will remove some of the vagueness and uncertainty which seem to surround this subject.

For the purpose of our subject we may regard light as having its origin at some heated body, which by virtue of its incandescence is capable of propagating vibrations in the ether with which it is immediately surrounded. The vibrations may be likened to those produced by throwing a stone into a lake. The ripples so formed may be taken as a graphical demonstration of the wave formation which the radiations from a heated body assume. These wave formations assume different wave-lengths dependent upon the rate of vibration of the molecules of the hot body, which in turn is dependent upon the temperature. For this purpose the wave-length of the vibration may be taken as the distance between one wave crest and the next one following, and is analogous to the "pitch" of a screw thread. The wave-length is maintained throughout the ether until the wave comes in contact with a body which has the power of either stopping or converting it into motion of different wave-length. Here again the previous analogy would apply, if the ripples caused by the stone come into contact with a body located in the water. The analogy, however, hardly suffices to demonstrate the complexity of the radiations proceeding from a luminous body, as these combine both light and heat rays, the frequency and wave-length of which vary with every temperature and degree of luminosity. It is in this way that the sun provides us with both light and heat. The ether, occupying the intervening space between the earth and the sun, becomes the mode of conveyance through which the energy is transmitted by virtue of the radiations having their origin at the sun's surface.

We have to regard the oxy-acetylene flame and the work under treatment from exactly the same point of view. The application of the flame to the work produces rapid vibration in the molecules due to the heating, the effect of which must be added to the vibrations produced by the flame itself.

Sunlight, as distributed over the earth's surface, is a combination of heat and light radiations, having a normal average wave-length resulting from the interposition of the solid matter, &c., in the atmosphere, which forms a natural protection to which the human eye is attuned. If man so harnesses nature as to produce artificial combinations, such as, for example, the flame or arc, he must exercise his ingenuity to provide himself with suitable artificial means of protection. Hence our subject.

The solar spectrum consisting of seven so-called primary colours—red, orange, yellow, green, blue, indigo and violet—represents but a small fraction of the energy radiated from a luminous object. It is a matter of daily observation that a piece of metal at, say, 700 deg. C., a cherry-red heat, radiates perceptibly more heat than light. When a body is heated, the first waves to be radiated are those whose wave-length are large. When the temperature approximates to 500 deg. C. light waves are produced which are just able to affect the optic nerve, and we are then conscious of the sensation of red light. On prolonged heating and raising of the temperature, further waves of shorter wave-length are added to the others, so that the colour of the body gradually changes, the waves which excite the violet sensation being added to the others at about 1,350 deg. C. Continued heating does not alter the colour of the now white-hot body, but causes it to emit radiations of low wave-length, invisible to the normal eye, but detectable with the aid of the photographic plate. "Solar" radiation, proceeding from a source at a much higher temperature than 1,500 deg. C. contains a very large

* Paper, slightly abstracted, read at the Meeting of the British Acetylene and Welding Association, on Thursday, June 10, 1920.

proportion of luminous rays. In Fig. 1, I have endeavoured to give an idea of the manner in which solar energy reaches us. The other waves radiated in all directions by the sun have different wave-lengths, definite vibrations or wave-lengths being accompanied by definite effects. It will be seen that the visible spectrum embracing wave-lengths lying between about 0·4 microns and 0·8 microns,* is bounded on one side by a series of vibrations of short wave-length—the actinic or chemically active ultraviolet waves—and on the other side by a series—the infra red—having a much greater wave-length, and commonly known as "heat rays." Beyond the infra red, a series of long wave-length electrical radiations occurs, with which we are not concerned for the present. This combination of heat, light and actinic rays is not confined to solar or stellar radiations. It is found in one form or another wherever a source of radiant energy exists, and where such a source of energy is a product of human skill and invention, whether as oxy-acetylene flame, electric arc, molten glass or blast furnace, it is essential that such delicate organs as the human eye should receive adequate protection from influences which are unsatisfactory because unnatural.

The scientific study of these different types of radiation is to-day a fine art, and various and elaborate devices are employed in the analysis of such radiant energy. It has been found possible to explore the infra red portion of the spectrum very accurately by means of such instruments as Professor Langley's "Bolometer." The principle of the instrument depends upon the change in electrical resistance of a thin strip of platinum due to change of temperature. A wide field has been explored by means of this instrument, and in Fig. 2 we have curves obtained in this way representing the distribution of energy other than chemical or electrical in : (*a*) The spectrum of sunlight ; (*b*) the spectrum of the incandescent positive crater of an electric arc between carbon poles. This diagram introduces us to the question of the absorption of energy by the transparent medium through which radiations are passing. The irregularity of the curve representing the distribution of the energy received from the sun is due to the fact that the earth's atmosphere itself absorbs certain wave-lengths, and there is evidence that other wave-lengths are absorbed by the relatively cool enveloping layer of gas which surrounds the sun. Were these selective absorptive powers not in existence, the dotted line shown would undoubtedly represent the distribution of energy curve for solar radiations. This diagram indicates very clearly the relation and the difference between solar energy and the radiations of a portion of the electric arc, as regards the so-called "heat rays." In the one, the point of maximum energy is found to be within the limits of the visible spectrum and actually consists of light rays of wave-lengths between 0·5 micron and 0·6 micron. In the other, the point of maximum energy is in the infra-red region, with wave-lengths greater than one thousandth of a millimetre (1 micron). This point is of particular interest to the electric welder, since it demonstrates very clearly the necessity of adequate protection against heat rays. This is, of course, only one small feature of the question. The energy radiated from the negative pole, and that from the heated vapours which constitute the arc, and are largely responsible for the violet colour of the light, are other by no means unimportant features, and will be touched on in a moment. Only about 10 per cent. of the radiant energy from an arc, other than a flame arc, is luminous, the remaining 90 per cent. consisting of non-luminous waves.

If we transfer our attention for a time to the other end of the visible spectrum, we find that the actinic nature of the waves existing beyond the violet, renders it possible to examine ultraviolet rays by photographic means. Spectrum photographs of ultraviolet radiations are to-day as exact as photographs of the visible spectrum. Specially-designed spectrometers have been constructed in which the radiations have a free and unobstructed passage to a sensitive plate. The waves are invisible to the naked eye, but the sensitive plate records wave motions outside the compass of the normal eye. In this way it has been shown, for instance, that in the case of an electric arc operating between carbon and iron, the light is considerably richer in ultraviolet rays when the iron is the positive electrode than when the carbon is positive.† Similarly, photographic methods have demonstrated that all ultraviolet rays of wave-length less than about 0·29 micron, emitted by the sun, are absorbed or scattered by the atmosphere. This absorption is not absolute, but is merely a scattering of the shorter waves, which reappear as radiations from the blue sky.

The oxy-acetylene flame when subjected to photographic examination is found to be peculiarly active as regards its actinic properties. The acetylene welder, working in close proximity to molten metal and a flame which is largely monochromatic, due to the sodium salts which form the basis of most fluxes used in the industry, has to guard against the highly actinic nature of the flame itself. The photograph, Fig. 3, demonstrates the latter point very clearly. It is an instantaneous picture of the flame of a special multi-jet blowpipe. It was taken in sunlight, and the camera was "stopped down" as far as possible. No detail is observable in the flame, which merely shows up as a white mass against the somewhat under-exposed surroundings. It was necessary to sacrifice details of cones and flame structure, in order to show even slightly the remainder of the picture. Such a condition arises from the intense ultra-violet activity of the flame, in contrast with the amount of ultraviolet rays present in the sunlight. The result shown indicates that the reflected sunlight is too weak in radiations of short wave-length to be able to affect the photographic plate in the same time as the flame. The action of the flame on the human eye under these conditions is similar to that on the sensitive plate, and is comparable with the effect which would be produced by gazing open-eyed at the sun itself without the interposition of any protective screen. In the latter case the greater percentage of the rays are luminous, in the former the danger lies in the non-luminous ultraviolet radiations.

Returning for a while to the subject of the electric arc, we find that it has been possible by the methods already mentioned to investigate very accurately the radiations from various arc systems. For example, in the case of the carbon arc a curve showing the energy radiated from the heated vapours which constitute the arc itself is shown in Fig. 4.* This curve shows that from the arc itself the greatest amount of energy is radiated as short waves near the violet end of the spectrum, and the violet colour of the arc is due to these waves. The small scale at the bottom of the figure

Fig. 1. ETHER WAVE DIAGRAM.

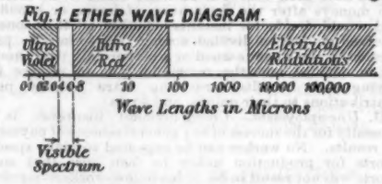


Fig. 2. DISTRIBUTION OF ENERGY CURVES.

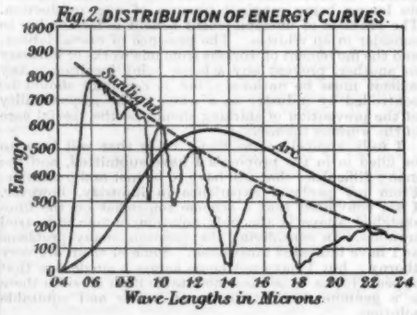
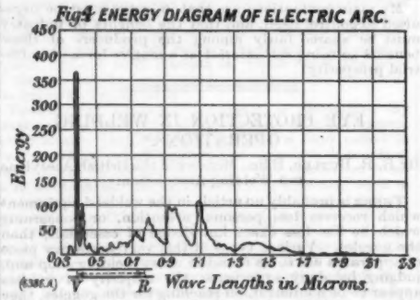


Fig. 4. ENERGY DIAGRAM OF ELECTRIC ARC.



shows at a glance the limits of the visible spectrum. When we consider electric welding as practised to-day, in which, in most cases, a flux covered metal electrode is employed, the problem of dangerous radiations is complicated by the production of the so-called "flame-arc." The strongly luminous arc produced when salts of potassium, rubidium and caesium, in admixture with calcium fluoride, are introduced into the arc stream, is an example of this. When the arc is struck between iron or copper electrodes, the metal itself produces a complicated mixture of waves of different lengths, the chief characteristics of which is their relatively high proportion of ultraviolet light. If, in addition, such salts as cryolite, zinc borate, or potassium magnesium fluoride, are by any chance present, the ultraviolet portion of the spectrum lying between 0·4 micron and 0·25 micron, will be found to be considerably intensified. The temperature produced by the formation of the arc is interesting from the point of view of infra-red dangers. The actual temperatures attained by various metals when used as electric arc electrodes have recently been measured by an optical photometric method.† The temperature of the carbon arc was found to be 4,200 deg. C. absolute. It was found that variations in current strength do not affect the temperature of the carbon arc, but in the cases of iron or copper increase of current density considerably increases the intensity of the light, and hence no doubt the temperature. In these cases the temperature remains constant from a certain current strength upwards, and this constant temperature is taken as the boiling-point of the metal.

These facts are of interest as showing the general injurious conditions which have been found to exist and which may at any time be encountered in the production of arc welds. In the production of oxy-acetylene welds there is no reason why the metal should be overheated to any great extent, since the intensity of the light is not sufficient to seriously interfere with the operator's vision. The condition of the metal is therefore entirely under his control, and since with a properly constituted flame the molten portion of the metal is surrounded by an envelope of reducing gases, tendency to high temperature due to the production of metallic oxides is practically eliminated. The heat energy liberated is nevertheless considerable, even under ideal conditions.

Both the arc and the oxy-acetylene flame are particularly rich in active non-luminous rays, and under present conditions the operator, whichever method he uses, is confronted with the necessity of combating radiations covering practically the whole range of the spectrum between wave-lengths of 0·1 micron and, say, 5 microns. It is evident that : (*a*) Infra-red waves, (*b*) ultraviolet waves and (*c*) luminous waves have to be guarded against, and of these three the luminous or "dazzle" effects are by no means the least important.

This combination of rays of different wave-lengths cannot but have injurious effects upon an unprotected eye, and it may be interesting here to consider the eye

FIG. 3.

itself, in the light of recent research. Experiment has shown that the cornea—the outer envelope of the eye—absorbs certain radiations, thereby preventing them from reaching the delicate interior portions of the eye. It is generally agreed to-day that the extreme ultraviolet rays of wave-length less than 0·295 micron (see Fig. 1) are stopped in this way, and do not reach the retina.* These vibrations, on being stopped, are converted into vibrations of a different frequency—either into light or heat waves. It should be noted at this point, that when any medium absorbs certain rays, the vibrations do not thereby cease to exist. The law of the conservation of energy steps in, and we find that such absorbed waves merely cease to vibrate with their own wave-lengths, and are transformed into vibrations of longer wave-lengths.

To return to the cornea, the ultraviolet vibrations having wave-lengths less than 0·295 micron are charged with producing such maladies as acute irritation, conjunctivitis, and, in addition, cloudiness of the cornea, which absorbs them. The injury known as "ophthalmic electrica," which practically amounts to a temporary sunburn of the eye, is attributed to these waves, and usually one finds that a few days complete rest will result in recovery. The other section of the ultraviolet waves, lying between wave-length 0·3 micron and the visible spectrum (see Fig. 1) is of a different character. These waves are not absorbed by the cornea, and actually penetrate into the interior of the eye. Being actinic they naturally affect the retina to a considerable extent, and the maladies known as colour scotomata, retinal degeneration, and glass-workers' cataract, are some of the injuries said to be due to this section of the spectrum. There is, however, considerable doubt concerning some of the above conclusions. The facts regarding the selective absorptive power of the cornea are established, but opinions differ over the relation between effect and cause. For example, while in one school the injury known as "glassworkers'" cataract, is attributed to the ultraviolet radiations, another school attributes the malady to the infra-red waves.† One reason for holding this latter view is, in brief, that the temperature of molten glass is approximately 1,400 deg. C., and this temperature is too low to give rise to any appreciable quantity of ultraviolet radiations. Moreover, since the water with which the eye is filled is very opaque to the infra-red rays, most of the energy radiated at 1,400 deg. C. must be absorbed into the outer coating of the eye, and, therefore, it is argued that the injury must be attributable to the infra-red.

Without entering into any argument on such a debatable point, it is interesting to note that apparently Sir William Crookes, in his work on protective glasses, was induced to accept this theory. More recently,

* 1 micron = one thousandth of a millimetre.

† Luckiesh, Trans. Illum. Eng. Socy., XI, page 472, 1914.

* Dr. W. B. Snow, *Physical Review*, vol. i, page 28.

† Hagenback and Langbein, Arch. Sc. Phys. Nat. Eenve, 1919, vol. i, page 48.

* Bell, Proc. Amer. Acad. Arts and Sciences, vol. xlviii, 1912, page 1.

† See Coblentz and Emerson, U.S.A. Bureau of Standards, Technological Papers, No. 93.

experiments performed on living fish and frogs with special reference to the cataract found in tropical countries, lends further support to the ultraviolet school.*

Researches by Aschkinass† have shown that infra-red radiations having wave-lengths greater than 1·5 micron (see Fig. 1) cannot reach the retina owing to the opaqueness of the aqueous humour contained in the eye for these wave-lengths. Similarly Luckiesh has computed the transmissive powers of the cornea, aqueous humour, crystalline lens, &c., for different wave-lengths.‡ As before mentioned, ultraviolet rays of wave-length less than 0·295 micron are stopped before they reach the retina.

The eye appears to be highly sensitive to vibrations in the region of the yellow portion of the spectrum (about 0·5 micron to 0·6 micron), about 97 per cent. of the radiations reaching the retina, while only 38 per cent. of the vibrations of wave-length 1 micron (infra-red) pass through the aqueous humour.

Having obtained a general view of the question of harmful vibrations, let us consider the more recent historical aspect of the problem.

In 1880, the name of Dr. Fieuzel, of Paris, was prominent in connection with yellow-green glass capable of absorbing ultraviolet rays. In 1905, Dr. Otto Hallauer, of Basel, Switzerland, produced a smoky green glass for which he claimed similar properties. Two German men of science

Fig. 5. INFRA-RED TRANSMISSION CURVES.

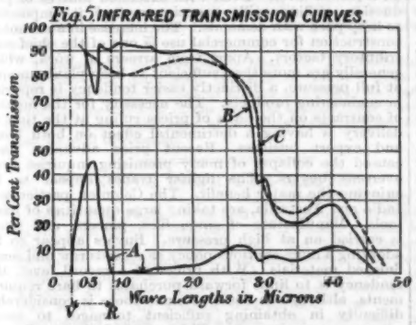
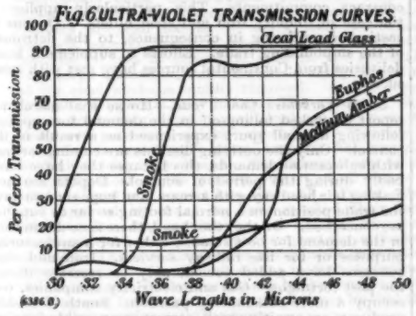


Fig. 6. ULTRA-VIOLET TRANSMISSION CURVES.



produced, in 1907, the greenish-yellow glass known as "Euphos," two particular shades of which were adopted officially by the German Government. In our own country, the most notable work in this connection was undoubtedly that of Sir William Crookes, who was persuaded in 1909 to investigate the causes of the cataract which is so prevalent in the ranks of the glass-workers. A Glassworkers' Cataract Committee of the Royal Society was formed§ and finally, in 1913, a glass was obtained which absorbed a large proportion of the radiations at either end of the spectrum. This glass left the visible portion of the spectrum practically unchanged, whereby the judgment of colour values was not hampered in any way. This glass would, however, be of little service to this industry. As I have already mentioned, the "dazzle" when welding, is by no means the least fatiguing feature, and it is imperative that satisfactory means be found to protect the eye from practically the whole spectrum.

Sir William Crookes actually produced four types of glass, each of which had particular properties: (*a*) *High Infra-red Absorption.*—Fig. 5, curve A, is an example of the results obtained in an examination of Crookes' sage green ferrous glass. The transmission in the green is about 45 per cent. The maximum transmission in the infra-red is only about 11 per cent., and it has been found that the glass transmits only about 5 per cent. of the infra-red radiations emitted by a molten mass at 1,000 deg. C. The Crookes' ferrous glass No. 246‖ intercepted 98 per cent. of the heat radiations, but was not entirely effective in stopping ultra-violet rays. (*b*) *High Ultra-violet Absorption.*—Crookes prepared some interesting specimens of this type. Glass No. 240 (also a ferrous glass) entirely intercepted the ultra-violet, but was not so successful as regards the other end. In fact, it only stopped 88 per cent. of the infra-red rays. The glass transmitted 36 per cent. of the luminous rays, and was of a smoky green colour. Another glass (No. 202), a neutral-tinted specimen, transmitted 17 per cent. of the heat radiations and was opaque to rays of shorter wave-length than 0·383 micron. Only 25 per cent. of the luminous rays were transmitted. (*c*) *High Transmission of the Luminous Rays.*—Fig. 5, curve B, shows the type of curve obtained on examination of this glass. The transmission in the visible varies from 90 per cent. to 75 per cent., and the glass is not nearly as efficient as his green glass in stopping wave-lengths slightly greater than those of the extreme end of the visible spectrum. The amount of infra-red transmitted by this glass is about 55 per cent. of the total radiation of a melt at about 1,100 deg. C. It may be interesting here to examine a curve (C) showing the infra-red absorptive power of a typical yellow goggle-glass examined by Coblentz and Emerson.* It is shown here as a dotted line, and its contour suggests very strongly the probability that a similar formula to that employed by Crookes has been used in its production. Six of these glasses belonging to type C were specifically mentioned by Crookes, and, to take the two extremes as examples, we find that glass No. 187 (a cerium glass) which transmitted 99 per cent. of the luminous, only succeeded in stopping ultra-violet as far as wave-length 0·365 micron, while it transmitted 73 per cent. of the heat. Glass No. 238, also a cerium glass, which transmitted 71 per cent. of the luminous, had about the same transparency to ultra-violet as No. 187 (above) and transmitted 66 per cent. of the heat. (*d*) *Low Transmission of the Luminous Rays.*—These glasses were designed for use in the Polar exploration work and similar undertakings, where snow goggles are essential.† Crookes' glass No. 248 only transmitted 30 per cent. of the light, and was of dark neutral colour. Its heat absorption was about 47 per cent., while its ultra-violet absorption was satisfactory as far as wave-length 0·355 micron. Another glass (No. 249) transmitted 63 per cent. of the light, 49 per cent. of the heat, and absorbed ultra-violet to the same extent as No. 248 above.

It is evident, therefore, that the problem of finding one glass which combines within itself the necessary conditions for adequately filtering the whole of the spectrum is a gigantic one. Indeed it is doubtful whether such a combination is possible. When ultra-violet rays are absorbed by a medium they are converted into waves of longer wave-length. It is therefore possible for a lens of protective glass to hand on to the eye more light (*i.e.*, luminous rays) than it receives. This is an interesting point. Moreover, should the conversion of short wave-lengths proceed in a more marked manner, and produce heat rays instead of light rays, we should have an increase in the quantity of heat rays passed on. The quantity of heat formed in this way is probably too small to be measurable, and insignificant as regards its effects on the eye, yet it is a point of importance in the problem. To quote Sir William Crookes: "Whilst bearing in mind that the chief object of this research is to find a glass that will cut off as much as possible of the heat radiation, I have also attacked the problem from the ultra-violet and the transparency points of view. Taking each of these desiderata by itself, I have succeeded in preparing glasses which cut off over 90 per cent. of heat radiation, which are opaque to the invisible ultra-violet rays, and are sufficiently free from colour to be scarcely noticeable when used as spectacles. But I have not been able to combine in one specimen of glass these three desiderata in the highest degree. The ideal glass which will transmit all the colours of the spectrum, cutting off the invisible rays at each end, has still to be discovered."

After the success achieved by Sir William Crookes, came the European War, in the course of which, America, deprived of many of her pre-war sources of optical supplies, had to depend on herself for such items as spectacle glasses. It was no longer possible to purchase them in Europe, as had been her custom, and her experimentalists rose to the occasion and produced glasses which behaved in a similar way to the European glasses. A number of firms in the United States are now manufacturing glass which they claim to be of unusual value for eye protection purposes. Many of these have been accurately studied, and their behaviour under different conditions ascertained, the results of such investigations being readily accessible in various publications, some of which are quoted in this paper.

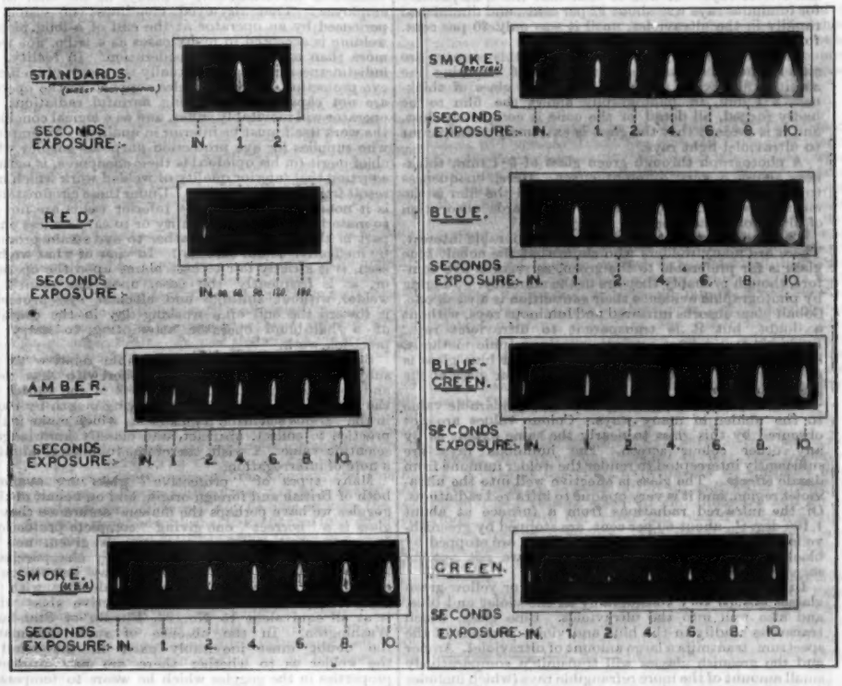

STANDARDS.
SECONDS EXPOSURE:-
IN. 1 2
RED.
SECONDS EXPOSURE:-
AMBER.
SECONDS EXPOSURE:- IN. 1 2 4 6 8 10
SMOKE.
SECONDS EXPOSURE:- IN. 1 2 4 6 8 10
SMOKE.
SECONDS EXPOSURE:- IN. 1. 2. 4. 6. 8. 10.
BLUE.
SECONDS EXPOSURE:- IN. 1. 2. 4. 6. 8. 10.
BLUE-GREEN.
SECONDS EXPOSURE:- IN. 1. 2. 4. 6. 8. 10.
GREEN.
SECONDS EXPOSURE:- IN. 1. 2. 4. 6. 8. 10.

FIG. 7. PHOTOGRAPHS OF OXY-ACETYLENE FLAME THROUGH VARIOUS "PROTECTIVE" SUBSTANCES.

A careful examination of available results brings to light several features which complicate the issue: (*a*) The thickness of the glass has an obvious bearing on the quantity of energy intercepted; (*b*) the colour of the same kind of glass may vary in different parts of the same melt; (*c*) even when using the same formula, different melts will give different tints of the one colour; (*d*) length of time of heat treatment will cause variation of the colour.

It is futile, therefore, for an experimenter to attempt to obtain figures for the absorptive powers of all the glasses for which their makers claim either a definite colour, particular properties, or (in some cases) merely a distinctive name. Nevertheless, bearing this in mind, it will be of value to study briefly certain experiments carried out by Bell* and by Luckiesh,† which show very well the differing properties of so-called "protective" glasses.

Some of the curves relating to glasses examined are shown in Fig. 6, in which the approximate limit of the visible spectrum is shown by the vertical dotted line. A number of photometric observations taken by myself may perhaps serve at this point to demonstrate some of these peculiarities, and the broad general principles upon which the use of colour screens is based. In Fig. 7. are reproduced photographs of the oxy-acetylene flame taken through a series of coloured "protective" glasses.* As a standard photograph of the flame, I adopted the instantaneous picture, which was found to be the only method of obtaining a sharply-defined image of the highly actinic, so-called "luminous" cone. Varying

* Burge, Trans. Illum. Eng. Socy., New York X, page 932, 1915.
† *Ann. der Phys.* vol. lv, 1895, page 401.
‡ *Elect. World*, October 25, 1913.
§ Phil. Trans., 1914, pages 1 to 25.
‖ For details and formulæ concerning these numbers see Phil. Trans., 1914, pages 1 to 25.

* Bureau of Standards, Technological Papers, No. 93.
† The goggles worn in Captain Scott's Antarctic Expedition were of a light green tint, which they found particularly comforting to the eyes. ("Scott's Last Expedition," vol. i, page 466.)

* Proceedings, Amer. Acad. Arts. "Science," vol. xlvi, No. 24. April, 1911, page 669.
† Trans. Ill Eng. Soc., New York, vol. ix, page 472, 1914.

time exposures were then made on a continuous film, the standard instantaneous view of the flame being taken at the commencement of each series, and care being taken to prevent actinic rays reflected from surrounding objects from reaching the lens and thereby fogging the film.

In the first place these photographs show clearly the opaqueness of red glass to ultraviolet rays, and also the relative actinic properties of the cone, and the volume of gas constituting the "flame." The actual exposures given are shown in each case, and it will be seen that even at 180 seconds exposure, only the cone is visible. The thickness of the specimen of glass used was 2·1 mm. The objections to glass of this colour are, of course, its transparency to infra red, and its colour, which causes considerable eye fatigue.

An amber coloured glass, of thickness 2 mm., gave results showing some transparency to ultraviolet light. One of the great objections to this colour is its transparency for luminous rays. The colour, as in the case of red glass, causes a certain amount of ocular distress when in use.

Two different "smoke" glasses were examined in this way, one being an American product, of thickness 2·2 mm., and the other English, 2·5 mm. thick. Their behaviour is very different. Two curves relating to smoke glasses, taken by Luckiesh, display a similar lack of uniformity. The transparency of this type of glass to visible light cannot under any circumstances be taken as a criterion of its transparency or opacity to ultraviolet rays. It will be seen that the transparency for luminous rays was about 92 per cent., and diminished rapidly in the ultraviolet, until it was only 20 per cent. for a wave-length of 0·3 micron.

The usual goggle glasses met with in this country are either blue or green, and the result of exposing the sensitive film while using a cobalt blue glass of thickness 2·1 mm. in photography shows the film to be badly fogged, all detail of the cone is completely lost, and it is evident that the glass is extremely transparent to ultraviolet light rays.

A photograph through green glass of 3·1 mm. thickness shows a very different effect. Here, opaqueness to ultraviolet light is very marked, and the film is the most satisfactory one obtained, as regards absorption of ultraviolet radiations.

These results seem to me to be of considerable interest. There are many welders who claim that the cobalt blue glass is far preferable to the green, as regards eye comfort, though probably they are in the minority. Judging by photographic evidence their contention is a weak one. Cobalt glass absorbs infra-red and luminous rays, without a doubt, but it is transparent to ultraviolet rays. Luckiesh, using more intricate spectrographic methods, has demonstrated conclusively that cobalt blue glass is as transparent to ultraviolet rays as is clear glass of the same thickness.

On the other hand, green glass is of considerable value to the welder in many ways. Colour values are not obscured by this glass to nearly the same extent as by any other colour screen. The luminous rays are sufficiently intercepted to render the welder immune from dazzle effects. The glass is effective well into the ultraviolet region, and it is very opaque to infra-red radiations. Of the infra-red radiations from a furnace at about 1,100 deg. C., about 60 per cent. are stopped by greenish-yellow glass, 60 per cent. to 80 per cent. are stopped by black glass, and about 95 per cent. are cut out by sage green glass.

In general, the red, amber and yellow or yellow-green glasses absorb very considerably in the violet and blue, and also well into the ultraviolet. Blue glass, which transmits readily in the blue and violet portions of the spectrum, transmits a large amount of ultraviolet. Amber and the greenish glasses will transmit a comparatively small amount of the more refrangible rays (which includes some ultraviolet) if the glass is too thin, or of too light a tone.

A combination of two or more glasses is sometimes used, and one frequently finds red and cobalt blue combined. A better combination in the light of modern knowledge is to be found in red and a full green glass. Such a combination should under reasonable conditions form a very opaque screen for all radiations, and is of particular value in electric welding where a decidedly opaque glass is essential.

The colour of a glass is, of course, dependent upon the particular wave-lengths which it cannot absorb, just as the colour of the petals of a flower is due to the particular spectrum colour which they cannot absorb and therefore reflect. Glasses which have considerable absorptive properties in the violet and ultraviolet (thus producing amber and yellow glass) do not as a rule display marked absorptive powers in the infra-red. These glasses are very transparent in the infra-red regions. On the other hand, those glasses whose absorption in the yellow and red is considerable (and whose colour is therefore blue-green) usually have considerable absorptive powers for infra-red rays.

If, therefore, the aim be to afford protection from infra-red waves, the bluish-green, sage-green or yellowish-green glasses should be used. If, on the other hand, it is ultraviolet light which has been absorbed, as is more particularly the case in this industry, red, amber, yellowish-green, or sage-green glasses are necessary. Should it be considered advisable to guard against both sources of irritation, sage-green, or yellow-green glass would appear to provide the greatest degree of immunity. In any case, whether using oxy-acetylene or arc, such glass must be employed as will obstruct the visible rays to a very considerable extent, and it is necessary to wear the darkest glasses which can be conveniently used, whether yellow-green, sage-green, or black-green.

What are the conditions actually existing in welding shops to-day? Is the operator being safeguarded to any appreciable extent? One can hardly think so!

Whatever other considerations enter into the case, two opposing forces are always in action, viz., the relatively high cost of manufacture of a useful optical protective glass, and the buyer's demand for a cheap article. These two fundamentals must under no circumstances be overlooked. Moreover, of the two, the latter wields by far the greater power. A manufacturer confronted with the incessant demand for an article which is low in price, must either produce such an article or lose his market. He has little or no choice in the matter, with the inevitable result that in order to cut costs the efficiency of the article suffers. Inferior qualities of glass are used in the construction, and as a result a type of goggle is produced having the appearance of a serviceable article, yet whose opacity to injurious radiations may be decidedly doubtful. Why? Because neither the purchaser nor the operator have sufficient exact knowledge as to the essential requirements of suitable eye-protection apparatus. The operator who understands his business has complete control of the welding apparatus which he is manipulating. He is able to adjust the flame to suit his requirements; he can give the metal any necessary preliminary heat treatment which the job in hand requires. His materials, in the shape of filling rods and fluxes, are standardised, and always available for his use. Yet in spite of the high technical perfection of the welding conditions, imperfect welds continue to be produced. May it not be that the fault is traceable, not to the welder, or materials, but actually, in the end, to the employer? That dry-eyed cloudiness of vision experienced by an operator at the end of a long piece of welding is accepted in many cases as a trifle, not worth more than a moment's consideration. In reality, this indistinctness of vision is actually the result of inefficient eye protection. If the goggles supplied to the operator are not capable of absorbing harmful radiations, the operator will inevitably suffer, and as a logical conclusion the work itself must be inferior in quality. An employer who supplies for eye protection purposes goggles whose chief merit (in his opinion) is their cheapness, is actually courting that inferior quality of welded work which must result from indistinct vision. Under these circumstances, is it not possible that many inferior welds are not due to materials of doubtful quality or to carelessness on the part of the operator, but rather to eye strain produced by ineffective colour screens? In view of what we have seen, is it strictly fair to cast blame upon the operator, or, as is frequently the case, upon the plant? A welder without suitable and efficient eye protection is toward the end of a working day in the condition of a half-blind operator attempting to carry out precision work.

Such is the information available relative to this subject. Work in connection therewith has been, and is being, carried on in all parts of the world, and the details of such work are appearing month by month in the various scientific publications which make it their practice to collect, abstract, and classify knowledge of scientific value. I wish, therefore, to finish to-night on a note of interrogation.

Many types of "protective" glass are available, both of British and foreign origin, and on behalf of these goggles we have perhaps the makers' assurance that the glass is a "correct" one giving "complete protection." In many cases no such assurance is given, nor unfortunately is it always asked for by the purchaser. Moreover, there is to the best of my knowledge no official publication in this country dealing with the merits of particular makes of protective glass which is at all equivalent to No. 93, Bureau of Standards, Washington. In the absence of such information the doubt must inevitably exist in the mind of the welder as to whether there are any protective properties in the goggles which he wears to compensate for the loss of visibility occasioned by the colour of the glass.

Is it too visionary a scheme to suggest that the British Acetylene and Welding Association should make itself responsible for the issue of some form of certificate in connection with all goggles claiming to be protective? The production of curves such as are here reproduced is a very tedious process, and except for purposes of research is unnecessary. On the other hand, the transmissive power of any medium can be ascertained approximately in a very simple manner by means of a spectrometer fitted with a quartz optical system in place of the usual glass lenses, &c. Such instruments are readily obtainable, and are simple and reliable in operation. Our friends in France, from whom we in this country have received and still receive so much valuable technical information, are sufficiently united and sufficiently strong to boast a central laboratory, where work can be carried on under satisfactory conditions, and whose results are made available for the general good of the whole industry. Is such a position unattainable in this country? I do not think so! In this, as in so many other human concerns, unity of purpose will achieve results. A central laboratory under the control of the association is capable of becoming, not merely a clearing house of technical information, but actually a source of strength to the association. Its duties would be many and varied, and amongst these I would suggest the early consideration of suitable types of goggles for the protection of operators. The conditions as to construction, sale and use of these glasses are at present chaotic, and there is certainly room for some system of co-operation with the manufacturers. A form of recommendation, issued with the authority of this association, would be of immense value from many points of view. To mention two only, the welder himself would be assured of adequate protection and, further, the supervision of an article such as this would be yet another step forward in the direction of standardisation of supplies, to which we are steadily but surely advancing.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The settlement of the steam service men's strike has allowed a general resumption in iron and steel production, but it will be several weeks before the staple trades get into full swing again. Though only 2,000 men were directly concerned in the strike, their precipitate action involved the lock-out of no fewer than 30,000 iron, steel and engineering workers, and in the course of a 10 days' deadlock, industry sustained a loss estimated at between 400,000*l.* and 500,000*l.*, and the workers sacrificed over 90,000*l.* in wages. The strike has served no definite purpose. The men have gone back to work on precisely the same terms as formerly operated. A six weeks' armistice is declared; meantime the question of whether the enginemen concerned shall be paid by the hour or shift is to be submitted to the Industrial Court of Arbitration. According to representative steel makers, the damage to local industry has been almost as extensive as in the case of the recent moulders' strike. Work urgently required for delivery, especially in the case of machinery for shipment, has been delayed, substantial arrears piled up, and new business suspended. Especially is the effect noticeable at the rolling mills, where congestion has been a marked feature for many weeks past. Pressure for supplies is on a record level. Even with extended sources of production, rolling mills proprietors find it impossible to keep pace with demands. The increase in automobile construction for commercial use is one of the chief contributory factors. Apart from arrears of work, which generally are more than sufficient to keep plant running at full pressure, a distinctly easier tendency is reported in engineering products. The necessity for the making of contracts on the basis of prices ruling at the time of delivery is having a detrimental effect on both home and export business. Recent price advances have caused the collapse of many promising inquiries from oversea buyers. The lighter trades appear to be enjoying the major benefit. The Colonies, particularly India and Australia, are taking large quantities of hand tools. Manufacture of saws, files, pincers, and pliers is carried on at high pressure. Buyers appear to be adopting a more cautious policy as regards raw and semi-finished materials. With prices at a record level, the tendency is to limit forward purchases to bare requirements, although in some sections there is considerable difficulty in obtaining sufficient tonnages to cover contract commitments. This particularly applies in the case of foundry iron and steel billets. Output of castings is suffering in consequence, to the detriment of the shipbuilding trade. Efforts to supplement home deliveries from Continental sources have met with small success.

South Yorkshire Coal Trade.—House coal merchants report a marked falling-off in the demand for supplies, following a small spurt experienced as a result of decontrol. Only the outlying districts are coming forward with substantial demands, this because they have fared badly during the period of control. Depots are now making fair headway with arrears, and hope soon to have the trade position on a normal footing so far as supplies are concerned. On the other hand, there is no diminution in the demand for best steams, either for manufacturing purposes or for the railway services. Iron and steel concerns have added considerably to reserves during the past fortnight. Gas and electricity companies, too, occupy a more satisfactory position. South Yorkshire producers are awaiting with interest any possible development in the control of foreign trade so far as the Humber traffic is concerned. Quotations:—Best handpicked branch, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty slacks, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Customers find it quite impossible to secure anything like sufficient supply of Cleveland pig-iron. The shortage indeed appears to be more acute than ever. Commendable efforts of producers to make up, to some extent, deliveries to Scotland caused by the recent dockers' strike, have met with considerable success, but despatches to customers beyond the Tweed fall far short of satisfying needs. There are still no export quotations, makers adhering to their decision not to sell Cleveland pig-iron for shipment to foreign ports. For home consumption, No. 3 and the lower qualities are 217*s.* 6*d.* and No. 1 is 230*s.*

Hematite Iron.—There is very marked scarcity of hematite iron, but the situation in this branch is hardly so stringent as is the case with regard to Cleveland pig-iron. A little home business is passing, and occasionally small odd lots can be spared for sale to Continental buyers, but producers are well placed, and are not keen to enter into new contracts. For home purposes, Nos. 1, 2 and 3 are 260*s.* and No. 1 is 262*s.* 6*d.*; while for shipment to France, Belgium and Italy mixed Nos. are 265*s.* and No. 1 is 267*s.* 6*d.*

Foreign Ore.—Nothing new is ascertainable concerning foreign ore. With sellers inclined to take a rather firm stand, and consumers holding off the market, as not only have they substantial stocks, but they report large quantities coming forward against contracts, business is practically at a standstill. Users state that they

can still purchase on the basis of 49*s.* for best rubio, on the 17*s.* parity freight, Bilbao-Middlesbrough, which makes the ex-ship Tees value of 50 per cent. rubio, 59*s.* 6*d.*, as steamers from the Spanish ore port are being chartered at 27*s.* 6*d.*

Coke.—Coke keeps strong and in good request. There is considerable home business doing, heavy local needs receiving adequate attention, but foreign business is very awkward to arrange. Average blast-furnace kind is 62*s.* 9*d.* at the ovens, and quality low in phosphorus is 65*s.* 3*d.* at the ovens. There are buyers of gas-house product for export at 170*s.*

Manufactured Iron and Steel.—The finished iron and steel industries are running at as full pressure as circumstances permit. Manufacturers have vastly more work on hand then they can cope with, and are not seeking further orders. Opinion that pressure for supply will become less insistent in the near future is becoming more general, and most traders now hold the view that prices have touched top. Many Continental customers hesitate greatly to negotiate on terms that are offered, and rather serious American and Belgian competition is threatened. The following are among the principal market quotations: Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; rivets, 38*l.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 23*l.*; fish plates, 28*l.*; black sheets, 44*l.* 10*s.*; and corrugated galvanised sheets, 54*l.*

Transactions in Australian Coal.—A Middlesbrough firm has just completed the sale of 140,000 tons of Australian screened coal to buyers in Sweden delivered over the second half of the year, at a price, it is stated, 30*s.* 6*d.* below the rate at which similar British coal can be sold in Sweden.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The activity which has prevailed in the steel trade of Scotland during recent months has shown no signs of change, and the heavy demand continues. Producers are doing their utmost to increase outputs, but such is well nigh impossible, with raw material so scarce. Deliveries of hematite fall a long way short of the amount desired, and thus are the steelmakers being handicapped. For both ship and boiler plates there is a very constant demand, and shipbuilders are still having to mark time periodically through poor deliveries of plates as well as of other material. Users of structural sections are consuming very large quantities, and all that is being turned out at the steel works is rapidly removed. At the present time the demand is very heavy. The makers of black sheets are having a most exceptional run just now, and every ton gets very quickly cleared off. Pressure for deliveries is exceedingly great, and the full output is booked a long way ahead. The home trade is still absorbing most of the present output of all classes of steel material and export lots are small. Prices, which are supposed by many to have reached their limit, continue firm, but inquiries are not quite so numerous, as some buyers are holding back temporarily in the hope of a fall. The latter may come along in the near future, but there are really no indications in that direction in the meantime. The orders already booked ensure steady running well into next winter, and perhaps by that time the actual position may be clearer.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland have still much work on hand and are experiencing some pressure for deliveries. The recent advance in prices has had the effect of a slight check on new business, but the position will settle out all right before present orders get worked off. The many works in the district are all busy and a very large tonnage is being turned out, and what is of no little importance is the fact that all of it is earmarked long before it is ready to be trucked.

Scotch Pig-Iron Trade.—The position of the pig-iron trade of Scotland has not appreciably changed during the past week except that an all-round advance of 5*s.* per ton has been made in foundry iron. The different grades are as scarce as ever, and consumers are wondering when the present tension will ease, so that they can get ahead with their orders. The producers point is that everything possible is being done to get the last ton out of the furnaces, and so great is the demand and so much of the forward production is booked that present conditions are likely to continue right through the summer. The consumption is exceptionally high, but of course the output is rather less than it might be. Prices of foundry iron are now called 14*l.* 10*s.* per ton for No. 1 quality, and 13*l.* 10*s.* per ton for No. 3 quality, both being for new business, delivered locally. Hematite continues in very active demand, and deliveries to steelmakers are on a large scale, although not large enough for their requirements.

High Prices.—The very high prices now demanded, or perhaps more correctly required, by makers of iron and steel material have been the subject of much talk recently, but wherever the demand is greater than the supply such a state will prevail. With raw material so dear and wages on a scale unheard of in history it stands to reason that the prices of the various products must be high. Output has a lot to do with the position, as it falls far short of what it should be, but the "ca' canny" policy seems to have got such a hold nowadays that it will be difficult to root out. Quotations for iron and steel material never were higher, and it is doubtful if the top has yet been reached. Labour is not contented with its present reward for services, and there is a growing feeling for a further advance, which, if agreed to, will cause markets to become firmer. The end of such demands is not yet in sight, and troublous times ahead are almost certain. So long as wages remain even on their present high level and outputs continue so poor it is rather difficult to see how quotations can be reduced. In the hope of an easier tone, however, buyers are, in some instances, holding off as long as possible, and there is evidence that a slightly uneasy feeling prevails in some quarters, but it is doubtful if there is any real justification for this nervous state on the part of buyers.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Miners' Drastic Proposals.—Some important matters were dealt with at the annual conference of the South Wales Miners' Federation held at Cardiff this week. One proposal adopted was that the rules of the Miners' Federation of Great Britain should be so amended as to dispense with the necessity of requiring a two-thirds majority before declaring a national coal strike. The effect of the adoption of this proposal would be that only a bare majority in favour of a strike policy would suffice. The extremists endeavoured to press the matter even further and proposed that the power to declare a strike should be vested either in the Executive Council or in a delegate conference, but both these latter proposals were defeated. The extreme section was also defeated on a proposal to substitute day-to-day contracts for the present arrangement whereby the workmen have to give 14 days' notice to terminate contracts. An interesting discussion took place in regard to the cost of living, and the somewhat remarkable policy advocated that in order to counterbalance the present high cost of living there should be continuous applications made for increases in wages, and that if necessary strike action should be resorted to in order to secure the miners' demands. The balance sheet of the federation disclosed a fairly strong position. The membership has grown from 153,913 in 1913 to 185,044, and the funds from 29,613*l.* to 283,584*l.* Out-of-work pay amounted to 26,042*l.*, strike pay 17,359*l.*, and lock-out pay to 22,087*l.*, and the year's contributions have increased from 49,195*l.* in 1913 to 139,907*l.* in 1919.

The Coal Trade.—The new export regulations continue to disorganise the market, and operators find it almost impossible to bring business to a finality. The quantity of coal exportable by each colliery is so small that shippers experience the greatest difficulty in making up cargoes, while as soon as the quantity allocated to a particular country under the scheme has been reached further releases are refused. In one instance a cargo of 2,000 tons was made up from 19 different collieries, and in another case a cargo of 3,000 tons from 24 collieries. In many cases collieries have already shipped their export allowance, and are now compelled to send the remainder of their output inland. As a result of these restrictions and delay in the return of wagons sent inland it is feared that there will be many pit stoppages owing to a shortage of empty trucks. The continuous day shifts of coal trimmers came into operation on Monday, and this has aggravated operators difficulties, for it is feared that the railway companies will not be able to keep the men sufficiently supplied with coal to keep them fully employed during the day and return wagons to the pits ready for loading on the following day. In the circumstances, prices are nominal on the basis of 115*s.* for large and 95*s.* for smalls. Patent fuel makers have benefited from the new scheme for they are now able to secure smalls for manufacturing purposes round 75*s.*, against 92*s.* 6*d.* a week or so ago, and as fuel exports are not limited makers are making special efforts to increase their output which they have been unable to do because of the scarcity of coal.

The Iron and Steel Trades.—There is practically no alteration in the tin plate market. Business remains quiet. Buyers are holding off, anticipating a reduction in prices owing to the fall in the price of tin, but makers being well sold are not anxious to sell and are of opinion that the high working costs will make it necessary for them to keep up prices. Current quotation for the standard box is round 72*s.* 6*d.* Steel bars range from 27*l.* to 32*l.* and spelter is easier at 41*l.* 10*s.* to 42*l.*

MIDDLESBROUGH PIG-IRON SHIPMENTS.—Messrs. Wm. Jacks and Co., 5, East India-avenue, E.C., state that the shipments of pig-iron from Middlesbrough and Skinningrove in May last were, coastwise 13,487 tons, and foreign 18,426 tons; total 31,913 tons, as against a total of 51,840 tons last April, 22,622 tons in May, 1919, and 31,599 tons in May, 1918. Last May there was a great falling off in the shipments to Wales, China and Japan, Belgium and Italy.

AUTOMATIC GATES FOR WEIRS.—Automatic gates of the type which the firm of Stauwerke A.G., Zürich, lately introduced at the hydro-electric power station at Broc, on the Jogne river, are being adopted on several big weirs of the Vienne Department, in France. In one case the discharge openings of the weir have widths of 70 m. and 23 m. respectively, and are closed by gates of heights of 4·50 m. and 3·60 m. The gate at Broc has an effective height of 3 m., that is to say, it blocks, when in the vertical position, a water depth of 3 m. The gate is horizontally pivoted in its middle. Its counter weight, attached to the lower half, is not sufficiently heavy to withstand the full water pressure of the upper reach; but this lower half moves, about the pivot mentioned, in a special water chamber which communicates through a syphon with the lower reach. By the aid of a sluice, which is operated by hand, the hydrostatic pressure in the chamber is adjusted, and the gate is opened or closed.

NOTICES OF MEETINGS.

THE ROYAL AERONAUTICAL SOCIETY.—Tuesday, June 22, at 8.30 p.m., at the Central Hall, Westminster, the Wilbur Wright Lecture will be delivered by Commander J. C. Hunsaker, U.S.N. The subject of the lecture is "Naval Architecture in Aeronautics," and H.R.H. The Duke of York will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, June 23, at 6 p.m., Wireless Sectional Meeting, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. "The Development of Thermionic Valves for Naval Uses," by Mr. B. S. Gossling.

PERSONAL.—The Brightside Foundry and Engineering Company, Limited, Wicker Iron Works, Sheffield, inform us that they have acquired the business hitherto carried on by Messrs. Pullan and Mann, Leeds, the well-known makers of brick, tile and sanitary pipe making machinery. This business will be worked in conjunction with their present brick machine business.

PETROL TRACTION PLANT IN MINES.—The Commercial Secretary to H.M. Embassy in Brussels reports to the Department of Overseas Trade that by a recent decree published in the *Moniteur Belge* the law prohibiting the use of petrol locomotives in mines has been abrogated. Their utilisation will, however, remain prohibited in mines falling under the third class, that is to say, those where fire damp is particularly prevalent, but in other cases authorisation can be given by the provincial council concerned on the recommendation of the Chief Engineer and Inspector General of Mines.

CANADIAN ENTERPRISE IN AUSTRALIA.—The Department of Overseas Trade has received from H.M. Senior Trade Commissioner in Australia information which indicates that great efforts are being made by Canadian manufacturers to strengthen and extend the footing that they have of recent years gained in the Australian market. Prominent Canadian business men have arrived in the Commonwealth, bringing with them many tons of samples and have arranged an exhibition covering such varied lines as enamel ware, coppered and plated tin ware, galvanised hollow-ware, electrical goods, metal lathing, tacks and nails, hand pumps, axes, cast-iron hollow-ware, tissues, leather goods, cotton cordage and elastic webbing, jute, axe and other handles, house porch and verandah furniture, canoes and boat equipment, paints and varnishes. The advantages of reciprocal trade have not been overlooked, and high-class and attractive Australian products will in turn be offered to the Canadian consumer.

LOSS OF HEAT FROM TINNED PIPES.—In a paper read before the American Physical Society last December, T. S. Taylor described experiments on the heat losses from sheet tin as used in hot air and water pipes. He used three vessels, each 10 cm. diameter and 50 cm. long, filled with hot water and placed horizontally in a room free of draughts. The metal of the one vessel was bare, that of the second was covered loosely with asbestos, and the third vessel was wrapped tightly with asbestos. It was found that the vessels cooled according to the law $\theta = \theta_0 e^{-at}$, the values of a for the rate of cooling from the bare, loosely and tightly lagged vessels being 0·0046, 0·0066 and 0·0077 respectively. Thus the bare tin lost only 70 per cent. of the heat that the loosely-lagged vessel lost, and 63 per cent. of the tightly-lagged vessel. Hot-air furnace pipes should hence not be lagged. By painting the tin with aluminium or by dusting it with cool ashes the a was changed into 0·005 or 0·0048; the dusting had little influence on the cooling of the bare tin, therefore, but it raised the a for the loose asbestos sheet to 0·0069.

THE JORDAN ELECTRO-PNEUMATIC CRANE.—By controlling the working and braking of cranes with the aid of compressed air Franz Jordan, of Gross Lichterfelde, is said to have doubled the working capacity of cranes in metallurgical works, where quick operation is very essential, while at the same time reducing the primary cost and power expenditure. Jordan took his degree as Dr.Ing. fifteen years ago on the strength of a dissertation on the combination of electricity and compressed air in crane operation. With his system he adds a compressor and a Schönfeld-Jordan air-brake governor (with slide valve gear) to the crane equipment; he further uses brake wheels resembling fans, in the arrangement of the spokes, which are set like vanes, for rapid cooling, and finally he employs controllers for coupling the load motor in such a way that the motor itself runs uninterruptedly in one direction, without being reversed, and is only stopped when the shop shuts down. A greatly accelerated service, H. Geitmann says in *Stahl und Eisen*, of April 8 last, is obtained at low cost, and repairs, frequent with magnetic braking, are very rare. The pneumatic coupling was a few years ago adopted for a 10-ton traveller which now raises its load at 14·3 m. per minute and lowers it at 360 m. per minute; the brake wheel has a diameter of 600 mm. and a rim width of 130 mm., and absorbs 800 h.p.; the wear of the wooden brake blocks, which are lubricated, is very slight, and the cranes do more than twice their previous work. Another crane, in service day and night, is fitted with two electric motors for 7·5 tons and 4·5 tons respectively; the 60-h.p. runs continuously, and the coupling can, independently of the brakes, sustain and arrest the load at any moment.

EXCAVATOR FOR TRENCH DIGGING.

CONSTRUCTED BY THE BUCYRUS COMPANY, ENGINEERS, SOUTH MILWAUKEE, WIS., U.S.A.

(*For Description, see Page* 822.)

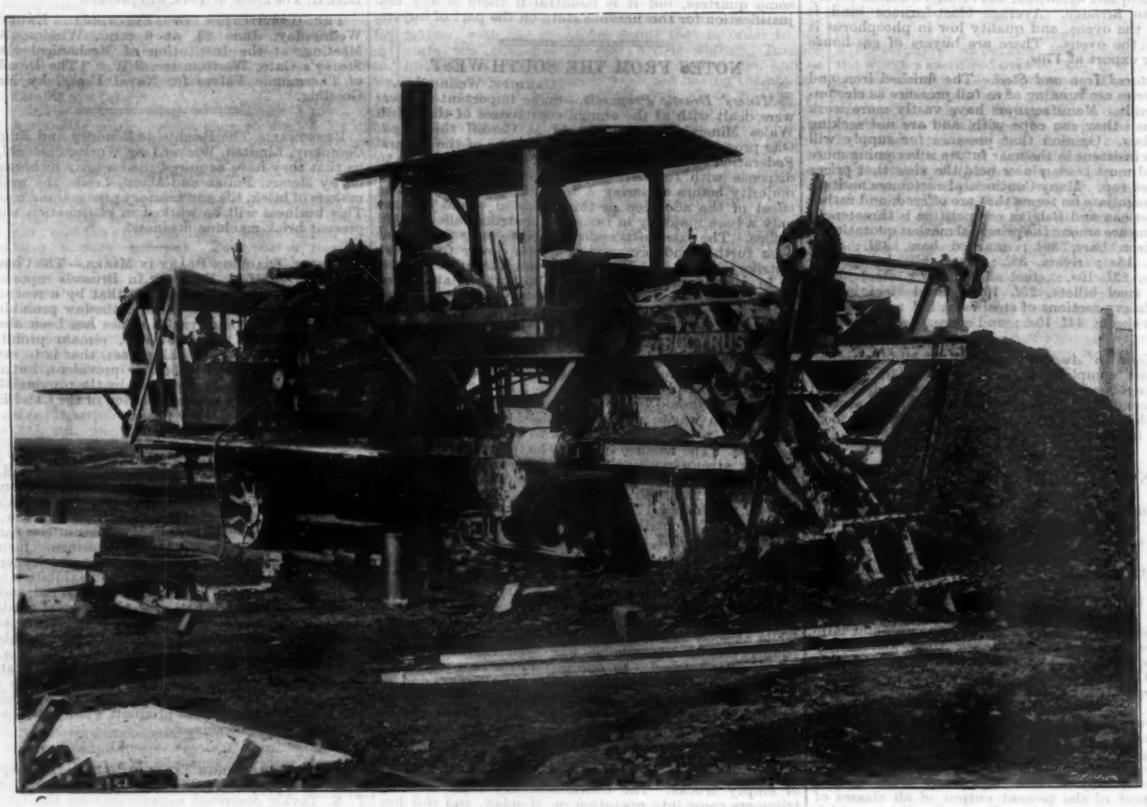


FIG. 1. GENERAL VIEW OF MACHINE.

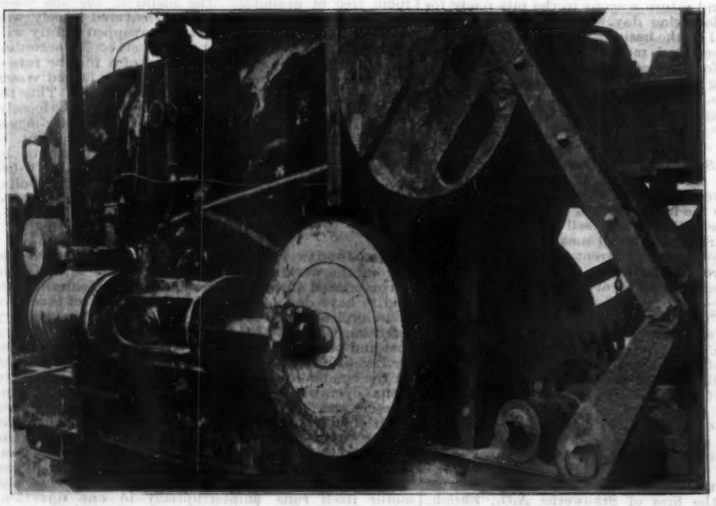


FIG. 2. MAIN ENGINE AND TRAVERSING GEAR.

FIG. 3. END VIEW SHOWING AUXILIARY CONVEYOR.

PEAT-FIRING ON THE SWEDISH RAILWAYS.—In consequence of the diminished import of coal and the high prices of coal, the Swedish railways have for some time past been using their own supplies of fuel to a much greater extent than before, says *Swedish Export*. Besides wood, which has been used to a very large extent on the private railways, peat has also been employed with success. The minor private railways in the South of Sweden, in particular, have led the way, but larger railways, too, have followed suit, as, for instance, a South Swedish private railway, with a mileage of 412 km., has found this fuel so practical that it considers it can entirely pass over to peat-firing and thus find a substitute for coal both for fast express and heavy goods trains. On this line the fuel (which corresponds to 17,000 tons of coal annually) has, during 1919, been peat and wood, while the consumption of coal has been brought down to only about 100 tons in certain months. The State Railways also have adopted peat on a small scale for use with slower trains. The State Railways have also had for some years past a factory working for the production of peat powder, a fuel which is considered to be quite as good as coal, but the production of which on a large scale involves considerable difficulties.

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(*For Description, see Page* 812.)

FIG. 6. THE SAW MILL.

FIG. 7. THE PATTERN SHOP.

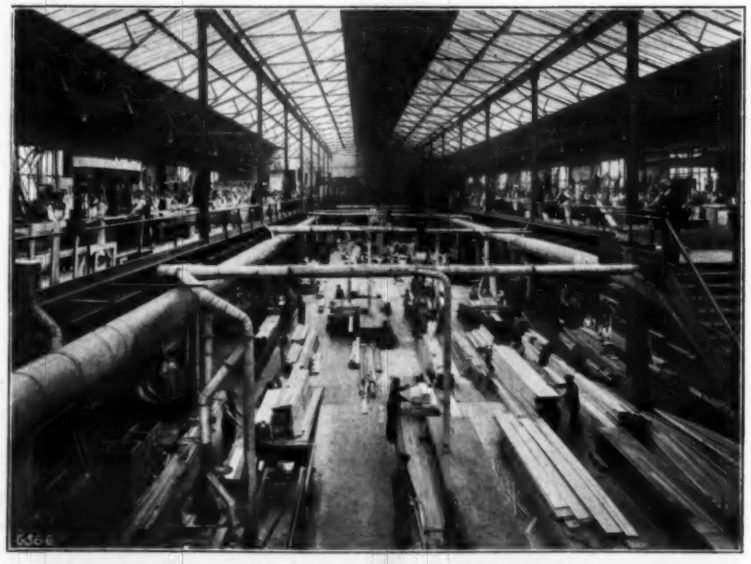

FIG. 8. THE JOINERS' SHOP; GROUND FLOOR.

FIG. 9. THE JOINERS' SHOP; GALLERY.

(*To face page* 816.)

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(*For Description, see Page* 812.)

FIG. 10. PLATERS' SHED, SHOWING SCREEVE BOARDS AND BENDING BLOCKS.

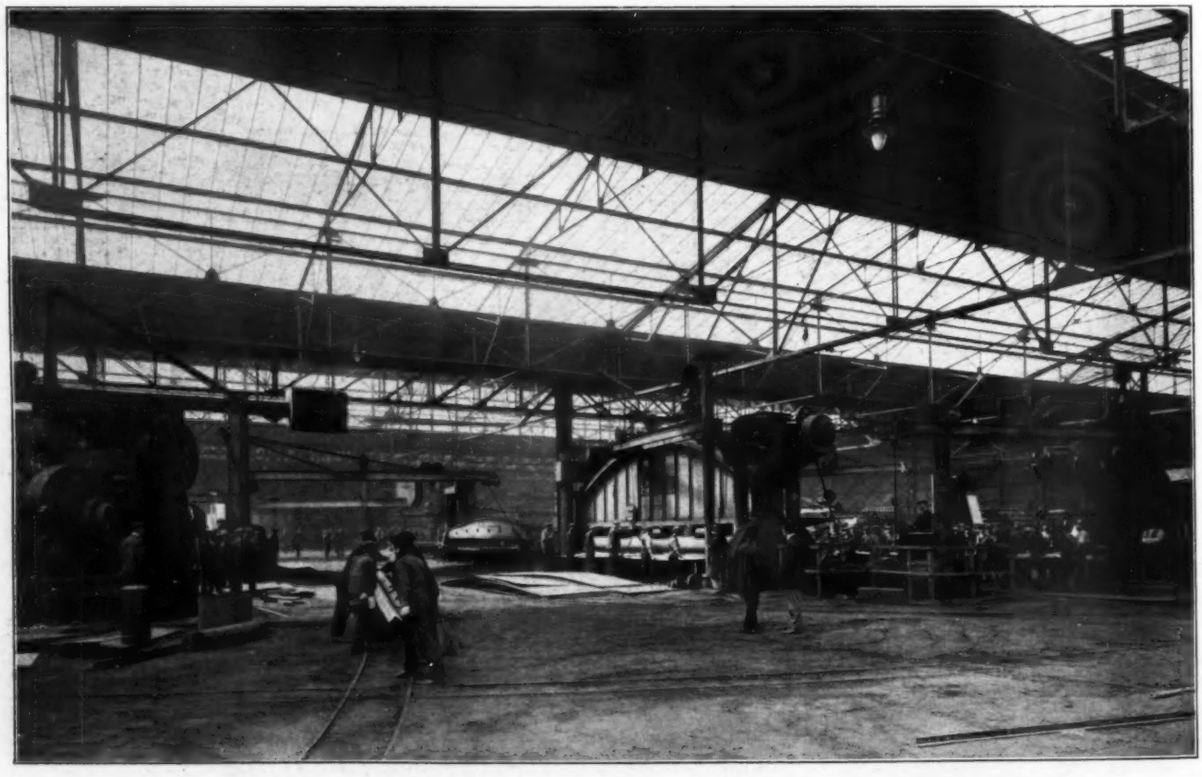

FIG. 11. PLATERS' SHED, SHOWING 2-IN. PLATE ROLLS.

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(*For Description, see Page* 812.)

FIG 12. THE ENGINE SHOP; MAIN BAY.

FIG. 13. THE BOILER SHOP; MAIN BAY.

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(*For Description, see Page* 812.)

FIG. 14. THE BOILER SHOP; MAIN BAY.

FIG. 15. THE BOILER SHOP; FLANGING BAY.

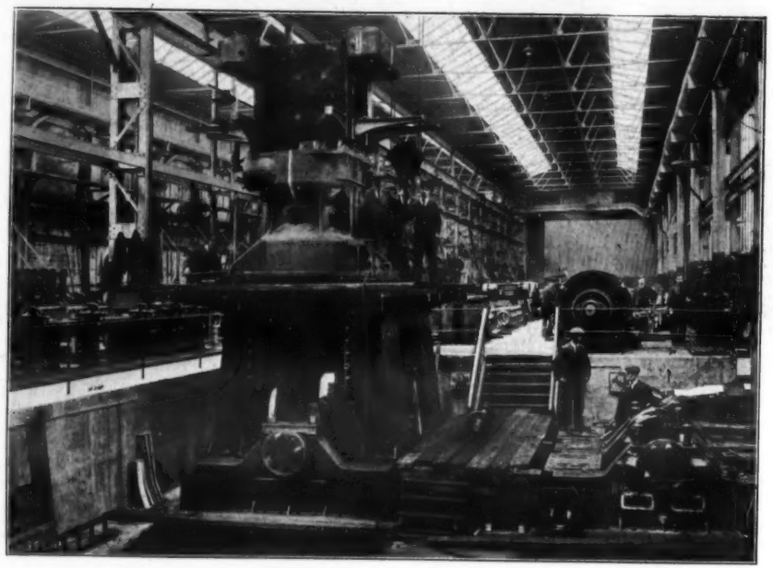

FIG. 16. THE OIL-ENGINE SHOP.

FIG. 17. THE FOUNDRY.

(*To face page* 817.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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With Four One-page Plates of the BIRKENHEAD SHIPYARD AND ENGINEERING WORKS OF MESSRS. CAMMELL LAIRD AND CO., LIMITED.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 827.

ENGINEERING.

FRIDAY, JUNE 18, 1920.

DOCK PROBLEMS.

THERE is something a little tiring to an engineer in the apparently endless discussion and attention which are now being devoted to matters of transport. The problem seems invariably to be treated in terms of generalities. Admittedly, engineering details and policy cannot usefully be made the subject of public controversy, but an unending harping on generalities can equally lead to no solution of present difficulties. If the railways, the docks and other transport agencies of this country are to be brought to a higher state of efficiency and a paying basis, it will be owing to the detailed labours of skilled administrators and engineers, and not to the most brilliant essays in general terms, or the most persuasive expositions in hazy outline. The present difficulty at bottom is a very simple one. Labour is receiving much higher wages than it did a few years ago, and the machine as a whole has not had time to adjust itself. Quite apart from advances since the war, the remuneration of labour has risen very greatly in the last hundred years. The machinery of social intercourse, however, kept pace with it. Indeed, it was the improvement in the machinery which made the advance possible. These improvements owed nothing to politicians, or boards of directors. They were worked out in drawing offices and in the brains of engineers, and the same places are the only places in which a solution of our present difficulties can be found. It is in a technical direction that improvement must lie, and technical improvements are brought about by the working out and application of much mechanical and scientific detail, and not by general conversations about electricity or oil.

We are led to these preliminary reflections on the general and the particular by a consideration of the various papers which have been read before the newly constituted Institute of Transport. All the contributions so far made have suffered from most of the vices of generality. We do not wish to make any attack on the new institute on this score. It has sinned in company with much older brethren, and it is able to put forward a more valid excuse than most. It is natural that in an absolutely new institution covering the amount of ground which the Institute of Transport must cover, there should be a desire that the early papers should be of a somewhat general nature and should sketch out some of the problems with which the institute may expect to have to deal. This desire, if it existed, has now been to a considerable extent satisfied, and we trust when the institute takes up its work again in the autumn that it will be able to provide papers of a more specific nature. In speaking of the Institute of Transport in connection with the technical detail for which we have pleaded, we are not falling into the error of thinking that it is an engineering society. It is not even a technical society in the ordinary meaning of the term, but that only makes careful avoidance of non-committal generalities all the more important. We are not pleading for engineering detail in the papers, but we are pleading for traffic and transport detail, and specific views or adequate data, on methods and principles.

We have said that we do not wish to make any attack on the Institute of Transport in connection with the matter of dealing in generalities, and even less do we wish to make an attack on Sir Joseph Broodbank for the last paper presented to the Institute and read by him before it on the 14th inst. Having said this, however, we trust we may be permitted to suggest that it was of a somewhat indefinite and discursive nature. As it was the first paper concerned with dock problems which had been presented to the Institute, a general review was allowable and even laudable, but we trust that some of its followers may take on a more specific colour. In the paper and in the discussion which followed it there were some references to public interest in dock problems. It was suggested that the lay press was apparently interested only in strikes and congestion. That the Institute of Transport should play to the gallery is the last thing that we would wish, but it may be suggested that the proceedings of the Institute itself might form a most admirable medium for the education of the lay press and the public to a more intelligent view and knowledge of transport problems. These problems are complicated, but they are at the same time specific, and if the Institute will give us specific treatments of specific subjects it may do something to wean the public and the press from their idea that the only interesting features of traffic troubles are the spectacular ones. The more responsible part of the lay press has already displayed considerable interest in the doings of the Institute of Transport. Let that interest be exploited to useful ends.

In our first paragraph we said that the essential problem of the day in transport matters was that the remuneration of labour had outstripped the capacity of the machine to make that remuneration square with finance. This leads to what appeared to us the most important part of Sir Joseph Broodbank's paper. Dealing with the constitution of port authorities, Sir Joseph pointed out that such bodies have a different constitution in almost every port in the country, but that, save incidentally in the municipal ports such as Bristol and Preston, labour has no representation on the board except in London. The Port of London Authority consists of 30 members, 17 of whom represent traders, and the remainder are appointed by Government departments, the London County Council, the Corporation of London and the Public Wharfingers. There are two direct labour members, one appointed by the Ministry of Transport and the other by the London County Council. In both cases the appointment has to be made after consultation with labour organisations.

Sir Joseph stated that the experience of the Port of London Authority had been that the labour representatives concerned themselves practically only with questions of wages and the conditions of labour. Occasionally some interest was shown in a question of management, but in general the larger matters of finance, trade and accommodation were neglected. He stated that he did not criticise this attitude of the labour representatives. They were ostensibly appointed to safeguard the interests of labour, and from their own point of view they had acted rightly. If they had swerved from the policy which they had adopted they would not have been recommended for reappointment by their organisations. They had been useful in explaining labour points of view to the Authority, and had sometimes been able to hold the men in hand against premature action. Apparently in the small proportion in which labour is represented on the Port of London Authority, Sir Joseph is reasonably satisfied with this type of attitude on its part. A large proportional representation he is not, however, prepared to consider, and holds that any popular representation is quite out of place in a commercial undertaking.

His last proposition in general terms we are not prepared to dispute, but we are far from satisfied with the state of affairs he describes as existing in

connection with the two sitting labour members. Accepting his account of that state of affairs, we can only describe it as radically unsound. Labour, even from the pure labour point of view, does not best serve its own interests by neglecting the "larger questions of finance and trade and accommodation," on which the prosperity not only of the port, but of labour itself, must ultimately rest. The correct attitude nowadays is not one of acquiescence in this indefensible attitude, but one of inquiry into the possibility of engendering a sounder point of view. Sir Joseph's paper was read in the year 1920, and we think he will be safe in assuming that any change which takes place in the constitution of port authorities subsequent to that year will show an increase, and possibly a considerable increase, in the labour representation. In these circumstances the continuance of the point of view which he describes may become a very serious matter.

It is a fairly common experience that responsibility has a steadying effect both on individuals and communities, and we cannot but trust that wider experience on port authorities, or elsewhere, will enable labour men to, sooner or later, shake themselves free from the narrow labour point of view. It is true that two labour representatives have now sat on the Port of London Authority for eleven years, and, according to Sir Joseph, they have lost none of their parochialism, but in defence it may be suggested that they have formed such a small minority that they may have feared to leave the particular patch of doctrine, or of interest, which they held it their first duty to defend. We think it is not too idealistic to suggest that the more power and with it the more responsibility which comes to labour, the more will it be enabled to embrace a wider view. In this idea we have the support of Sir Sam Fay, who may surely be described as a practical business man. Sir Sam Fay was in the chair at the reading of Sir Joseph Broodbank's paper, and he referred very specifically to this point. He thought that labour would, as time went on, take a wider and wider view, and in illustration of its possibilities in that direction referred to the good work which many of its representatives had done on municipal bodies.

Sir Sam went on to say that he would rather have labour inside dock boards, and similar authorities, than outside. He would even rather have it against him inside than against him outside. This appears to us all very sound. We are in favour of no violent socialistic experiments, but as labour has already achieved much power and will clearly, sooner or later, achieve more, we are certainly in favour of working with it, and even stretching a point to work with it, if by that means it can be brought nearer to a proper realisation of the true basis of prosperity both for itself and for the country. We have already stated the essential problem for docks and all other transport agencies—the non-concurrence between the wage level and the work level. The simple issue is, of course, greatly confused by questions of piecework, ca-canny and the rest, but above and beyond all these one has to face the fact that the present machine and the present methods were devised for a wage level altogether different from that now existing. The present wages can only stand if by some means the work done can be brought to nearer consonance with the wages paid.

It is in this vital matter that labour in authority can help and must help. It cannot in general devise new methods and new machines, but it can assist in the frank acceptance of them when they are devised. With a view to circumventing the labour point of view, labour-saving appliances are sometimes referred to as labour-aiding appliances. This is altogether the wrong way of going about things. Labour must recognise that its future, along with the future of all of us, depends on a frank acceptance and a proper utilisation of such appliances, and this frank acceptance is much more likely to be brought about by labour in the council chamber than by labour outside. It would probably not be going too far to suggest that Sir Joseph Broodbank would have had a different story to tell if labour had had a considerable representation on the Port of London Authority instead of a small minority. In any case, be that as it may, labour must recognise facts if we are to make progress, and one way to make it recognise facts is to give it authority.

THE BRITISH ACETYLENE AND WELDING ASSOCIATION.

An interesting paper was read before a meeting in London of this Association held on Thursday, the 10th inst., by Mr. R. R. Butler, B.Sc. We reproduce it in abstract on page 823 of the present issue. It gave the American rules for the use of welders using both acetylene and electricity, a brief history of the eye-protection means resorted to in the United Kingdom, an account of the work carried out by different scientists in order to provide adequate eye-protection to industrial workers in hot metal, the experimental researches made by the author in the same field, and his conclusions to the effect that operators, and welders more especially, were not safeguarded, from the point of view of their eyesight to any appreciable extent by the glasses generally put at their disposal. In this connection, he recommended the formation of a central laboratory, among whose duties should be the early consideration of suitable types of goggles. The conditions as to make, sale, and use of these glasses were at present chaotic, and there was certainly room for some system of co-operation with manufacturers. By adopting a system of this nature, the welder himself would be assured of adequate protection, and there would be another step forward made in the direction of standardisation.

In stating that the paper was open for discussion by the members, the President, Mr. G. F. Mason, added that the author had made it evident that the subjects should be gone into most thoroughly, since he had clearly pointed out that there was danger in making use of the glasses which were available at the present time for the eye-protection of operators.

The Chairman's remarks were endorsed by Mr. C. S. Milne, past-president. The author had collected in the scope of his paper all the records available on glasses for industrial uses, and had detailed his own work on the same subject. The paper would prove of very great value not only to welders using the oxy-acetylene flame, and to those who worked with the electric arc, but also to men employed at furnaces in which high temperatures were developed. It had very often been exceedingly difficult in the past to obtain good protective glasses. He (the speaker) would take up the optical considerations enlarged upon by the author in order to prove to his men the value of an adequate eye-protection. On the other hand, it should be noted that one had frequently to carry on a kind of warfare with the men to get them to use glasses at all. One explanation of this might be that in several instances one was not always sure of having provided the right article. In this connection, the paper would prove a most excellent guide.

The author was congratulated on his valuable contribution by Mr. H. G. Dixon, who asked what was the difference between a forge heat and the heat of the oxy-acetylene flame, or the heat produced in welding, from the point of view of danger to the eyesight. In steel works large forgings were manufactured from ingots, steel was, also, kept in a molten state in the furnaces for a comparatively long period; yet steel men were never seen wearing glasses, and he (the speaker) had not heard that their eyesight was injuriously affected by their work. The author, in one part of his paper, had referred to metal at comparatively low heats (700 deg. C. and 500 deg. C.), and had suggested that the non-use of glasses in this connection was liable to produce evil results; some steps should, therefore, be taken also to protect these men.

Mr. C. Hoddle, who followed, expressed the opinion that the author's work would result in giving the welders the glasses they needed. Glasses had been provided for them before, but these may not have been of the right kind. It was exceedingly difficult to get welders to wear their goggles, and some men who were experts in carrying out welding work would not touch them at all.

Captain D. Richardson, R.A.F., said that unfortunately the question had hitherto remained almost exclusively in the hands of scientists, and had not reached the workmen. In this country the goggle industry was at a standstill. Goggles could be purchased made of blue glass from several firms; it had been shown, however, that these were of no practical value, and this pointed to a serious situation. There was no choice, no selection of coloured glass could be made, and the direct result was that the welder put his goggles on one side. More work on the subject had been done in the United States than on the Continent. In regard to the steel-making industry, the goggle makers had not been able to replace the goggles having cobalt blue glasses by others of a more suitable character, from the eye protection point of view, because the men were so trained in watching the progress of the bath with the cobalt blue glass that a change would lead to the detriment of the quality of the steel. The finish of American goggles was, also, much superior to that of the goggles made in this country, from the standpoints of insulation, adjustment and the grinding of the optical glass with which they were fitted. All these features were of a high class in the American article. There were thousands of goggles used in the United Kingdom, yet one never came across any advertisement from goggle makers, and no attention seemed ever to have been paid here to the subject. The paper, he thought, should be circulated largely among employers whom the question was likely to interest.

The remarks of the previous speaker were endorsed by Mr. Waterhouse, who stated that matters were different in the steel-making industry. There was a noticeable difference in the concentration of the eyesight, this was not so permanent in steel-making as in the making of a weld. In steel works, only the chargeman and the first hand resorted to glasses at all. These men were so used to the deep cobalt blue screen, that a change would be disastrous from the standpoint of the quality of the furnace charge. He (the speaker) had to supervise many welding operations in the Goldschmidt process, and had always used a deep cobalt blue glass; in these operations, again, the glass was only necessary when tapping the crucible for running-in the weld, there was not a continuous application of the eyesight on the work. He also had experience in the working of small arc furnaces, for the making of ferro-alloys, and had found that a combination of cobalt blue and deep amber glasses formed a very soothing protection, the two gave a dark green colour—the amber colour being on the outside and the blue on the inside.

Mr. R. J. Moss thanked the author for having dealt so extensively with the subject. The hands of the employers having to carry out welding work might be said to have been forced hitherto; it was impossible to obtain any variety of glasses, and the only alternative left to employers was to worry the firms who could make them to supply the correct kinds of goggles. He (the speaker) had used a very dark red-yellow-green screen, which also looked "a dirty purple," and had found it most efficient. It was not possible in this country to buy goggles made of dark green glass.

Mr. A. Hoddle asked the author whether, in his researches, he had found the arc to be more harmful to the eyes than the oxy-acetylene flame, or *vice versa*.

In the course of his reply to the discussion, Mr. Butler said that from the point of view of danger to the eyes there was no difference between a forge heat and that of a weld. But in the welding operation, the welder's eyes were concentrated at a close range on the flame and on the molten mass for a lengthy period, and this did not obtain in the case of forge heat. In the latter case, also, the metal was heated to a semi-viscous condition only. The objection on the part of the men employed in steelworks to the wearing of goggles could be explained by the fact that these men had to walk about over the works, and the wearing of bulky goggles would have for effect to interrupt their vision. In this instance, closeness of operation did come in, but not so much length of time. That only scientific men had hitherto dealt with the subject under review was only too true; the men had not been taught, and he would have liked,

had that been possible, to have welders take part in the meeting so as to receive from them evidence of a practical nature. With reference to the welding of aluminium, the flux had an effect, and as this contained potassium salts, the rays were different. In carrying out the open-hearth process, it was a fact that the colour values should not be obscured, and the point in this connection was to arrive at goggles which did not obscure the vision. With regard to a combination of amber and blue glasses for electric furnace work, he might mention that Bell, in America, had combined a reddish amber with a green glass, which stopped both the infra-red and the ultra-violet rays. It was a particularly dense combination, but it covered both ends of the spectrum. As to whether the arc of the oxy-acetylene flame was the more dangerous, he would say that the vote went invariably to the arc.

At this point, Mr. Britten expressed the view that the Association might get into close touch in the matter with the Society of Glass Technology, a suggestion which was received favourably by all members present. The Chairman, at the close of the proceedings, congratulated the author on his exhaustive research work. He felt sure that one of its results would be that makers of goggles would have their attention called to the subject through the medium of the technical press, and that they would welcome at least, the opening pointed out to them for increasing their business.

THERMO-ELECTRICITY AND THE CONDUCTIVITY OF METALS.

WHEN Sir Joseph J. Thomson delivered the May lecture of the Institute of Metals, five years ago, on the "Conduction of Electricity through Metals*," he emphasised the fact that the gas-kinetic electron theory due to Riecke, Drude and himself, in its primary form, scarcely seemed to concord with actual facts. In order to arrive at a better approximation to the truth, the distinguished natural philosopher took up the deductive method, proceeding from the assumption that each metal atom contains an electric dipole. With these words—we do not quote quite literally—Professor Carl Benedicks, of the University of Stockholm, opened this year's May lecture of the Institute of Metals on "Recent Progress in Thermo-electricity," which he delivered in the lecture hall of the Institution of Mechanical Engineers on June 10. Proceeding in a different way, he stated, he had deduced, from the existing data on the conductivity of metals and alloys, conclusions concerning the mechanism of electric conduction in metals. His essential point was this: Metallic conduction is not to be ascribed to an "electron gas," filling up the space between the atoms, the metal acting as a cage for the electrons, but is due to the passing of electrons from atom to atom at the moments of the incessant collisions of the atoms which we assume, for other reasons, to occur even in solids. Without entering into much theoretical detail Dr. Benedicks outlined his considerations and demonstrated the experiments which have led him to his "phoretic electron theory of metallic conductivity." What the phoretic theory means, we will indicate in our conclusion.

When the electric conductivity of metals was first plotted against the atomic weight, the curve obtained was very irregular; silver and copper occupied quite exceptional positions, and the electric conductivity did not seem to fit into the periodic system at all, partly, it was suggested, because the metals examined were not pure. But on the phoretic hypothesis the electric conductivity k should be referred, not to the centimetre cube (as was done), but to the same number of atoms, such that $k_{at} = k\,A/S$, where A is the atomic weight and S the specific gravity; the curve then becomes more regular. On that hypothesis further a metal, the atoms of which are endowed with a high oscillation-frequency ν, should conduct better than one of low ν; the ν are known, and when the conductive capacity C is defined by $C = k_{at}/\nu$, this C will be a measure of the readiness with which the atoms take up or give up electric charges. When we plot the C against the atomic weight, the electric conductivity of the metals well conforms to the periodic system, better indeed than any other property of the elements. The alkali metals are found to have the highest conductive capacity, and they are known also to possess the highest electric affinity in their aqueous solutions, being most ready to give off electrons and to form positive ions; thus high electrolytic and high metallic conductivity go together.

At very low temperatures, as studied by Kamerlingh Onnes, metals become super-conductors, because—Dr. Benedicks suggests—the atoms then come into permanent contact (agglomeration). He can also account for the Joule effect, which, Decombe pointed out in 1914, the ordinary electron theory does not explain. But there is a drawback. One of the great achievements of the older theory was its explanation of the proportionality between electric conductivity and thermal conductivity (Wiedemann-Franz). Dr. Benedicks' phoretic theory fails here, unless a further, very special hypothesis be accepted: the high thermal conductivity of metals of high electric conductivity is the result of an "inner Thomson heat." "As in a heterogeneous conductor of variable temperature an increased equalisation of temperature occurs owing to the Peltier effect, so there should, in a homogeneous conductor likewise be an increased temperature equalisation on account of the Thomson effect; the electric currents assumed, though very strong, would be local micro-currents, the existence of which had hitherto not been discovered." In fact, the possibility of such currents was in contradiction to the law of Magnus, that in a homogeneous metal, whatever the temperature distribution, thermo-currents do not exist. After five years of research Dr. Benedicks has arrived at the conclusion that this law cannot be maintained.

Perhaps we had better put the problem plainly. The question is broadly whether temperature difference and heat flow always go together with potential difference and electricity flow. Though Franklin and Cavendish observed, with the aid of an electroscope, in 1769, that, when a hot and a cold bar of the same metal are brought into contact, the cold bar assumed a positive charge, and though Ritter noticed a flow of current under these conditions in 1798 with the aid of the galvanometer of those days, a pair of frog legs, the study of thermo-electricity is practically a century old, and began with Seebeck in 1821. Seebeck himself performed a great variety of experiments; he was followed by many distinguished scientists, and one may, in fact, say that most of the many new thermo-electric effects of the late decades are rediscoveries of forgotten observations of the past century. Three effects stand out prominently. When two metals are joined in a closed circuit, and the one junction is kept warmer than the other, the positive electric current runs through the hot junction from the metal of greater thermo-electric height to the metal of lower thermo-electric height. Professor Benedicks did not refer to this rule and the height scale, on which lead (thermo-electrically insensitive) marks zero, while bismuth is highly negative, and selenium highly positive; the convenience of this nomenclature is that in the Peltier and Thomson effects—the two other prominent effects—a current "running down" generates heat, and a current "going up" absorbs it. When an electric current is sent round the circuit of two metals, the junction is heated or cooled; it depends upon the metal (Peltier, 1834). When the circuit consists of portions of the same metal, the portions differing as to diameter, stress, &c., there is also heating or cooling (W. Thomson, 1856).

In briefly reviewing these investigations Dr. Benedicks distinguished three periods: A first period, 1821 to 1838, of active, somewhat uncritical experimenting; a second more critical period up to 1885, which finally accepted the law of Magnus, 1856, that no thermal current would occur in a really homogeneous metal, all apparent deviations being ascribed to impurities and to physical or chemical heterogeneity; and a third period, since 1898, which questions the law of Magnus. Professor Benedicks is the most eminent opponent of the law, and he demonstrated the reasons for his dissent.

His first experiment was one of Seebeck's. Two strips of metal (copper and constantan) are superposed; in the left half A B the strips are in direct contact (soldered), in the right half B C they are separated by a foil of mica; when they are heated at B, the end A becomes hotter than the end C. The explanation is that the Peltier effect transfers heat from B to A. If that explanation be correct for one homogeneous metal, Dr. Benedicks argues, the Thomson effect should also transfer heat, and a subdivided conductor should have a smaller thermal conductivity than the block of the same undivided metal. He proved this with the aid of calorimeters; a solid cylinder of copper and a bundle of copper wires of equivalent cross-section were both heated by contact with a block of copper, and both had calorimeters at the other ends. Carefully eliminating the many possible sources of error he found the conductivity of the divided copper to be up to 10 per cent. less than that of the undivided cylinder, whilst subdivision is not supposed to decrease the electric conductivity of a metal. These and other experiments further support a parallelism between the heat conductivity and the Thomson coefficient of a metal, as pointed out by Radakovic in 1907. The same parallelism appears in the next experiment. A rectangular strip of copper is vertically suspended in a horizontal magnetic field; the strip is heated along the right half of its upper edge and cooled along the right half of the lower edge. The temperature gradient will, owing to the local closed circuits, not be symmetrical, Dr. Benedicks stated, with respect to the middle line of the strip, and the strip is deflected when the field is turned on. The interpretation is difficult, and Ettingshausen and Nernst interpreted a similar experiment in a different way as a kind of Hall effect. However, Dr. Benedicks showed a thermal motor of this type, consisting of an upper and a lower ring of electrolytic copper; the motor turned about its vertical axis in one direction when the upper ring was heated, and in the other direction when the lower ring was heated by a small gas jet.

Passing to another series of experiments, Dr. Benedicks first heated a fine platinum wire (0·1 mm. diameter) by passing the flame along it in order to show, by the absence of currents, the homogeneity of the wire (Trouton's method). He then attached a globule of powdered quartz and sodium silicate to the wire; heating the wire now to the right or left of the globule he produced currents of opposite directions, proving that the globule had introduced a thermal asymmetry. We do not quite understand how this experiment can establish the reality of thermocurrents in a homogeneous metal. Seebeck had attributed such currents to the local hardening and softening of the heated wire; Fleeming Jenkin, in a very interesting British Association Report, 1862, had proved that oxide films, especially between two heated crossed wires, would set up thermo-couples of considerable intensity. Before meeting the general objection of the influence of oxide films in crossed wires Dr. Benedicks explained that he increased his asymmetry on the "strangulation" (constriction) principle, either by placing two globules of the kind mentioned close to one another, leaving a short length of colder wire between them, or by crossing two wires or rods of the same metal, graphite, &c., so that the cross-section would be very much reduced at the point of contact, near which he heated the one or the other leg. He suggested that graphite could hardly be oxidised and that when he welded two very fine platinum wires together at the crossing point, no oxide film could intervene; both these statements may be questioned. He relies chiefly, however, on the thermo-electric effect observed in mercury. Mercury is a liquid, as such free of internal stress, and obtainable in high purity; there it should be possible to decide whether the assumed Thomson effect is not after all merely a Peltier effect. Many experimenters have taken this latter view; but very careful experiments made with mercury in vessels of glass, or other materials, so constructed that hydrostatic-pressure stress could not arise, have convinced Dr. Benedicks that there is a thermo-electric effect in pure homogeneous mercury, and that it is of negative sign, as it should be. The effect is moreover proportional to the third power of the temperature, which is theoretically important,

* ENGINEERING, May 21, 1915, pages 577-579.

whilst it should be proportional to the first power in a heterogeneous circuit.

Having established that there is a homogeneous thermo-electric effect, Dr. Benedicks sought to determine whether there was inversely also a homogeneous electrothermic effect more general than the Thomson effect, as one should expect if the analogy of the phenomena were complete. In the Peltier effect an electric current gives rise to a temperature difference and a heat transfer, even if the temperature be originally uniform throughout the circuit; in the Thomson effect, on the other hand, the electric current seemed to produce a temperature difference only when there was a temperature gradient from the beginning. By a long series of experiments on various metals and alloys mercury, graphite, &c., Dr. Benedicks convinced himself that the analogy was complete. In his first experiments he again applied the constriction principle, taking crossed wires or wires turned down to smaller diameters in the central portion, or mercury in constricted tubes, sending a current through the circuit and looking for the establishment of a temperature difference on the opposite sides of the strictures. The difference observed u was found to be proportional to the current i itself. The difficulty of the observations was that the current would, of course, itself heat the circuit, especially at the points of contact or of reduced cross-section. Fortunately theory proved that this new effect and the resistance heating should be of the opposite sense and that, for some metals, the new effect becomes zero at a certain temperature, afterwards changing sign. Plotting the u against the i, Dr. Benedicks found that the curve for gold starts positive and becomes negative with increasing currents; the opposite holds for platinum, whilst in the case of graphite the curve is positive throughout. Studying the influences of various factors, including the length of the constricted portion in wires up to 5 m. in length, he finally observed the new electrothermic effect even in a long wire of uniform cross-section, a result which may look surprising, but which is in accord with his theory. The complete analogy of the thermo-electric and electrothermic effects in homogeneous and heterogeneous substances had thus been established, and two new (or formerly doubtful) Benedicks effects have been demonstrated: a thermo-electric and an electrothermic effect in a homogeneous circuit of one substance originally at uniform temperature throughout.

To account for these effects, especially those observed in perfectly homogeneous and uniform conductors, Dr. Benedicks has to assume that the amount of heat transferred by an electric current in a long conductor is not constant. As we proceed in the direction of the positive current, that quantity of heat must either increase or decrease, according as the heat transfer is in the positive or negative direction; otherwise no homogeneous electrothermic effect could be observed. That brings us back to the phoretic electron theory upon which Dr. Benedicks touched only briefly. If the electric charges be carried by the atoms and be not free, the increase in the kinetic energy of the atoms, and hence the heat generated, must be equal to the work done and must be proportional to i^2, whether the atom in question preferentially assume a positive charge or a negative charge. That preference is not unimportant in other respects, however. Supposing an atom inclines to assume a positive charge ϵ. Let it rebound between two atoms I and II, and let a potential difference V be established such that the positive current flows from I to II. In position I the atom will assume a positive charge; owing to that charge it will be accelerated on rebounding until it reaches II and gives up its charge, to be reflected at now constant velocity. On colliding with I again, it is again accelerated, and so on. In this mechanism of conduction the average kinetic energy of the atom in position II must be greater than the average energy at I by a constant amount $\epsilon V/2$, and that signifies that the temperature in II must be higher than in I. Similarly it may be shown that for atoms inclining to assume a negative charge, the temperature would increase in the direction of the negative current. The former case would be that of platinum and of constantan, the latter that of copper. Copper would be inclined to take up electrons, to associate them, platinum be inclined to discard electrons, to dissociate them; lead, in which there seems practically to be no thermo-electric effect, would as readily associate as dissociate electrons.

We have given expression to criticisms of Dr. Benedicks' views. We need not point out that he is a distinguished metallurgist, who has not overlooked the objections raised, and a very skilful experimenter; he had no assistance in his many successful demonstrations last week. There was no time for mathematical deductions. We only hope that these thermo-electric researches will be persevered in. The study of thermo-electricity seems pre-eminently to be fitted to reveal to us the real nature of the phenomena of heat and electricity.

OIL FUEL INSTALLATION ON THE "AQUITANIA."

AT the present moment there is but little need to urge the advantages of oil over coal as fuel for steamship propulsion, and if any such need existed the fact that our premier steamship company have considered it worth while to lay up their largest vessel for a period of nearly eight months to enable the conversion from the latter to the former fuel to be effected is ample evidence that such advantages really exist. The main considerations which affected the decision of the Cunard Company to equip the Aquitania for oil fuel burning were the great saving in labour and the increased regularity of steaming in comparison with coal firing, but the change will doubtless give some increase of speed, and it will certainly add to the cleanliness and comfort of the ship.

We have already illustrated and described the ship and its machinery very fully in our ninety-seventh volume,* so that it is only necessary to remind our readers that she was built by Messrs. John Brown and Co., of Clydebank, and is propelled by Parsons type turbines directly coupled to four propellers. The turbines are of 60,000 h.p., and the average speed is 23 knots. Steam is supplied by 21 double-ended Scotch boilers, working under Howden forced draught and having eight furnaces each, so that 168 furnaces in all have been equipped. The boilers are arranged in seven groups of three each. Two groups are placed in each of three forward boiler rooms and the after boiler room contains one group only.

The work of reconditioning the ship has been carried out at the Armstrong yard of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, at High Walker-on-Tyne, which has recently been very fully described in these columns. The vessel itself is, in fact, visible on the extreme right of Fig. 3, on Plate XX, which accompanied our issue of March 19 last. The work has involved the reconstruction of the original coal bunkers for the storage of oil, for which purpose all the bunker bulkheads have been specially stiffened and all joints have been made oiltight. In most cases stout double-riveted joggled plate straps have been fitted over the plate landings. Alterations to the plating and riveting of all steam pipe trunks and passages which penetrate the cross-bunkers, have also been necessary. Wash bulkheads have been fitted in all bunkers to diminish the effect on the oil of the ship's motion. The side bunkers, which extend for the whole length of the boiler rooms, about 369 ft., are 18 ft. wide for the greater part of their length, diminishing to 6 ft. wide at the forward ends. These tanks are divided into two groups by the anti-rolling tanks, which occupy a length of 32 ft. Oil is also stored in three large athwartship bunkers, one of which is placed forward of No. 1 boiler room, one between boiler rooms Nos. 1 and 2, and the other between boiler rooms Nos. 2 and 3. Six double-bottom tanks under the No. 2 boiler room have also been arranged for oil carrying, the total capacity in the vessel being 7,800 tons, which is sufficient for the double journey across the Atlantic and the oil can thus be shipped at New York. Of the total quantity, 5,200 tons will be carried in the side bunkers, 1,900 tons in the athwartship bunkers, and the remaining 700 tons in the double-bottom tanks. The side tanks and the double-bottom tanks have been fitted with steam-heating coils to increase the fluidity of the oil in cold weather, and in settling the proportions of these coils, allowance has been made for the use, in the future, of oil of higher viscosity than that at present employed. There are no heating coils in the athwartship tanks, as their situation between the boilers will keep the oil at a sufficiently high temperature. Four settling tanks, each of 60 tons capacity, have been constructed in each of the athwartship storage tanks, and two settling tanks of similar capacity have been incorporated in the side storage tanks on both sides of the vessel at the after end of the No. 4 boiler room. The arrangement, it should be noted, gives two settling tanks for each group of three boilers.

The oil used is Mexican petroleum residue having a flash-point of 168 deg. F., which is 18 deg. higher than the minimum requirements of the Board of Trade in this respect. It is burned on the White system, in which the oil is sprayed by pressure only without the use of compressed air. The oil is, however, heated on the way to the burners by passing through steam tubular heaters.

The system is the invention of Mr. W. A. White, and the burners, as well as the pumping and heating installation, have been supplied by Messrs. Brigham and Cowan, of South Shields. A duplicate set of pumps and heaters has been provided for each group of three boilers, so that there is very little risk of a shut down owing to failure of this part of the installation. In general it may be stated that exceptional care has been taken in the pumping and filling arrangements in the ship to avoid the possibility of breakdown. Suction and filling mains of 8 in. bore run along on both sides of the ship for the whole length of the boiler rooms. In each boiler room these mains are cross-connected, and shut-off valves are provided to enable the system of one boiler room to be completely isolated from the others.

Four connections to the filling pipes are provided on each side of the vessel, and by this means it will be possible to take on board the whole fuel supply in 6 hours from a tanker fitted so that all four connections can be used simultaneously. Using only two filling connections, 2,000 tons of oil has been bunkered in 4 hours at the Armstrong yard. This is, of course, a matter of very great importance in that it renders it possible, if necessary, to turn round the ship in less time than would be required for bunkering coal. One of the chief advantages of oil fuel is, however, the avoidance of the loss of steam which occurs with coal fuel from cleaning the fires. It is calculated that, in the case of the Aquitania, in which the practice was to clean 28 fires in each watch, the loss from this cause amounted to about 8,000 h.p. every 4 hours. Oil fuel can, of course, be supplied continuously and a constant pressure of steam maintained at all times; this should have the effect of increasing the speed of the vessel as well as of reducing the boiler repairs.

It may be interesting to recall the fact that the Aquitania left Liverpool on her maiden voyage on May 30, 1914, and completed the journey to New York, a distance of 3,181 miles, at an average speed of 23·1 knots. The return journey was made at an average speed of 23·45 knots. She had just completed three round voyages when war broke out, and the vessel was immediately converted into an armed cruiser for patrol work. She afterwards served as a hospital ship, and later was used as a transport for the conveyance of American troops. After the armistice she was employed for the repatriation of troops and in passenger traffic, so that it was not possible to lay her up for reconditioning and conversion to oil-fuel burning until the end of last year. Messrs. Armstrong must certainly be congratulated on the completion in such a comparatively short space of time of the large amount of work involved. It can easily be imagined that the pipe work alone formed a very serious item in the contract, but in addition to the work of conversion for oil burning, Cumberland apparatus has been installed for protecting the boilers and condensers from corrosion, and the opportunity has been taken for extending the passenger accommo-

* See ENGINEERING, vol. xcvii, pages 619, 655, 678, 693, 727, 818.

dation and redecorating the vessel generally. There can be little doubt that the new features will be greatly appreciated by the travelling public when the vessel resumes her ordinary duties. Her first voyage under the new conditions will commence from Liverpool on July 17 next, and, although no special attempt at record-breaking will be made, it will be extremely interesting to see what effect the new oil fuel installation has on the speed of the vessel.

NOTES.

Connecting-Rod Bolts.

It is doubtful if any technical institution, in this or any other country, has given such close attention to the practical details of the craft with which it is concerned, as has the Diesel Engine Users' Association. Many communications have been read and discussions held on such matters as the design of connecting rods, pistons, &c. The most recent point to be dealt with has been connecting-rod bolts, a subject which was discussed at the last and at previous meetings. In the course of the discussion some interesting points were brought forward by Mr. Charles Day. Mr. Day stated that the stresses which caused trouble with connecting-rod bolts might be divided into those due to excessive friction of pistons, those due to improper tightening of the bolts and those due to slack bearings. In connection with the manufacture of bolts he advocated the heat-treatment of the bar instead of the heat-treatment of the bolt, since the bar being of uniform cross-section internal strains were avoided. When bolts were heat treated there was danger of internal strains occurring at the bottom of threads or at other parts where change of section took place. Mr. Day described a method of marking bolts so as to permit of accurate measurements being taken which would show at any time if they had stretched or twisted.

Ball-Bearings for Horse Vehicles.

In our issue of May 28 last, on page 715 *ante*, we illustrated and described the construction of some ball-bearing hubs for horse-drawn vehicles, made by the Skefko Ball Bearing Company, Limited, of Luton. Since then we have witnessed some trials of these hubs made at the London Aerodrome, Hendon, and it may be of interest to give some particulars of these trials to supplement the information contained in our previous article. To compare the starting effort required with plain bearings and ball bearings, two four-wheeled delivery vans were employed, the vans being exactly similar in all respects, except that one was fitted with plain bearings and the other with Skefko ball-bearing hubs. The vans were tested on the smooth, level floor of some covered tennis courts, and the van with plain bearings was found to require a starting effort of 81 lb. when loaded with 15 cwt. Under similar conditions the ball-bearing van required a starting effort of only 57 lb., and when the load in this van was increased to 30 cwt., the starting effort was only 77 lb. In another test, on a different part of the floor, the van with plain bearings and a load of 30 cwt. required a pull of 110 lb. to start it, while the ball-bearing van, under exactly similar conditions, started with a pull of 46 lb. This greatly-reduced starting effort is obviously of considerable importance in parcel delivery work in which the vehicle is stopped and re-started at frequent intervals. A further series of tests was made to demonstrate the advantage of the ball-bearing hubs in hill climbing. These tests were carried out on Greyhound Hill, near the Aerodrome, with single-horse and pair-horse box delivery vans, and also with contractors' tipping carts. Two carts of each type were provided, one having plain hubs and the other ball-bearing hubs, and, to determine the effect on the horses, the pulse and respiration rates of the animals were measured both before and after each journey up the hill. The horses and vans were then interchanged, by attaching a horse first used with a plain-bearing cart to one of the carts with ball-bearing hubs, and *vice versa*, and the measurements were then repeated. The complete results are not yet available, and it is difficult, in any case, to present them in terms appreciated by engineers. The fact that the ball-bearings reduce the strain on the horses can, however, be shown by one example. The pulse and respiration rate of the horse attached to the plain-bearing tip cart with a load of half a ton were 46 and 16 respectively, before the climb; and 82 and 40 respectively, after the climb, whereas the corresponding figures for the horse drawing the tip cart with ball-bearings were 76 and 30 after the climb. The improvement is, of course, due entirely to the reduction of axle friction; no form of bearing can reduce the vertical component of gravity against which the horse has to work, nor the rolling resistance due to the character of the road surface. Inasmuch as these two sources of resistance constitute such an important percentage of the total resistance which a horse has to overcome in the performance of his daily work, it is not to be expected that a large reduction in the total amount of that work can be effected by the employment of ball-bearings. It should nevertheless be pointed out that the more level the roads traversed and better their surfaces, the more important will be the reduction of resistance which will result from the use of ball-bearings, and in any case it is certainly desirable to avoid expending animal energy in overcoming resistances which can be reduced materially.

LITERATURE.

Glass Manufacture. By Walter Rosenhain, B.A., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory. Second edition, largely re-written. London: Constable and Co., Limited. 1919. [Price 12s. 6d. net.]

Eleven years have elapsed since Dr. Rosenhain published a description of glass manufacture, and in that period much has been effected, both by those practically concerned in the industry and by research and experiment in the laboratory, to improve the manufacture and to promote the progress of the glass trade. Like may other industries that of glass has felt the pressure of the times, and has recognised that science and production should be associated in intimate alliance. This book, by its wide and illuminating survey of the general procedure, should attract public attention and strengthen the support necessary to a resuscitated industry. It is not addressed principally to the manufacturers of glass, but rather to the users of glass. In non-technical language, it explains how certain results are produced, the difficulties that attend many of the operations, and the means by which they have been overcome. An authoritative account is the more necessary, because the increased attention given to the subject, in consequence of being thrown on our own resources owing to the altered conditions of trade, has widened the circle of operations and introduced an improved technique. On the one hand, we have been compelled to produce glass of special qualities, and on the other, processes that met with common approval have become obsolete and have been superseded by others more economical and more scientific.

Two cases of a very different character tend to limit the description of the procedure. Many manufacturers having achieved a successful result by experiment, believe their interests best served by keeping the process as secret as possible. On the other hand, operations that have been public property for many years, defy complete explanation from a strictly scientific standpoint, notwithstanding the labours of distinguished opticians, theoretical and practical. In such instances, we are in face of an accumulation of empirical data which "while they have been productive of great direct practical results have left the science of glass still in a very elementary condition." The public, who are unwilling to believe that a substance so common as glass conceals any secrets, will not readily subscribe to this view. Accustomed to think of glass as a transparent, hard and brittle body, its real nature and constitution are overlooked, and some mental effort is required to regard it as a "structureless solid" or a "congealed solution" in which a number of chemical substances are mutually dissolved. The process of "congealing" as ordinarily conducted involves no change of structure or rearrangement of molecules, but simply an increase of viscosity till the body behaves like a solid. Forces or operations of a very complicated character are at work during cooling, however, and the outcome is not always that the manufacturer expected or desired. Some of these changes, such as that known as "devitrification," in which the process of crystallisation is manifested, admit of explanation on physical grounds, but others more subtle have hitherto baffled inquiry. Dr. Rosenhain suggests two significant illustrations which should offer a strong incentive to further investigation. No one has been able to explain the relation between chemical composition and the physical properties of refraction and dispersion of light. Practically unlimited experiment has resulted in producing some kinds of glass particularly suitable for optical investigations, but no law has been discovered that enables the optical qualities to be predicted from a known chemical combination. Equally inexplicable are some of the mechanical problems encountered in manufacture, such as the roughing of a glass surface when brought into contact with metal. A well-known instance occurs in the process of rolling. Other peculiarities need explanation, and great will be the reward that will attend ultimate success. But one great difficulty stands in the way of all such researches. The behaviour of small quantities of molten glass, as treated in the laboratory, differs greatly from that observed in the large volumes handled in commercial undertakings. The influence of furnace gases, of rapid cooling, of contact with containing vessels, are all "enormously exaggerated if ounces, instead of hundredweights, or tons, of glass are used for experimental purposes."

The object of the author is to supply, in addition to the description of the manipulative operations, the principles governing each, and as far as possible this plan has been pursued, but these elementary facts connected with the chemistry of glass explain the impossibility of carrying out this programme in its integrity. But the occasional omission of theoretical information has not prevented the production of a very instructive book, that was much needed in the revival of the industry. It covers a wide ground and presents the salient facts in an interesting light. Two introductory chapters on the chemical and physical properties of glass inform, or remind, the reader of the limitations imposed on manufacture, and of the efforts made to remove those restrictions. The range of bodies that can be obtained in the vitreous state is small, and the scope of the glass-maker is practically confined to varying the proportions in which the materials, usually silicates and borates are used. But every alteration entails a change in the behaviour of the product, both during the process of manufacture and in subsequent use. In ordinary life, we are not accustomed to regard glass as subject to changes, other than breakage, yet moisture and carbonic acid act on glass to a measurable extent, especially if an excess of alkali is used in the making. Very ordinary observation will show the effect of the deposition of crystals of carbonate of soda on "soda" glass. That corrosive liquids should attack glass is more easily apprehended, but except due precautions are taken, their action is less vigorous than that of alkaline solutions, which have the power of abstracting the silica. Water under steam pressure is an active corroding agent as the gauge-glass tubes on steam boilers too frequently testify. Glass exposed to strong sunlight, and more especially to ultraviolet rays, undergoes a change of colour, but here we are on the borderland of the unknown and the cause of the change is one of the matters that remains obscure.

Another limit to the choice of materials is imposed by the cost and rarity of the ingredients. Transport and storage have also to be considered as controlling the selection on the commercial side. Further, the amount of impurities mixed with the raw material is highly important, for owing to the prized quality of transparency in many kinds of glass, defects of colour are very objectionable and can be easily detected. A chapter devoted to the description of the most suitable materials shows that the choice is fairly extensive, and the sources whence these may be derived, widespread. In this connection it is significant to note that during the war, when the

potash deposits of Stassfurt were cut off, successful attempts were made to produce, without potash, those kinds of glass in which the use of this ingredient was thought to be indispensable. Only optical and decorative glass suffered slightly by the substitution of soda for potash.

The materials used in the construction of pots and crucibles in which the glass is melted call for the same care in selection as those that enter into the glass itself. Under favourable circumstances the life of a furnace is not long, and in its process of deterioration, the condition of the furnaces exerts no small influence on the quality of the output. The subject of "refractories" is becoming one of enormous importance, and in its limited application to the glass trade deserves the careful consideration Dr. Rosenhain has bestowed upon it. Leaving on one side all minor details, the main consideration that determines the choice of a suitable refractory is the position it will occupy in the furnace. Those parts that come in contact with the molten glass will be constructed of "fireclay," or a silicate of alumina, because this material, though not completely immune to the dissolving action of the fused glass, is capable of offering a very considerable degree of resistance. On the other hand, silica brick, which is energetically attacked by the liquid glass, can only be used for the roof and upper part of the walls and even here the dust and escaping vapours will in time effect a chemical combination and consequent deterioration. The effect of fluxing impurities in the refractory clay is not negligible, but like unequal shrinkage and expansion, or cracking and "spalling," these are details that must be decided by the circumstances prevailing in each individual case. It may be added, however, that all attempts to determine generally the refractory value of a clay in terms of the ratio of silica and alumina and to the amount of the fluxing oxides present, have met with little success.

The importance of a proper choice of refractories recurs in discussing the construction of the most economical form of furnace. The author states that in many cases the refractories employed are not capable of resisting the temperature they would attain if fully exposed to the internal heat, about 1,500 deg. C., and to prevent a collapse, the walls are purposely made thin and air-cooled. The efficiency of the furnace is thus deliberately sacrificed on account of indifferent or unsuitable material used in the construction of the furnace. Another point in furnace construction is often overlooked. It is possible to make the walls too thick under the impression that thermal efficiency must be improved by preventing the passage of heat from the interior to the external surface, overlooking the fact that increased thickness implies increased exterior surface, and more heat may be lost from the increased surface than is saved by the greater resistance offered by the wall.

The mechanical process of grinding and thoroughly mixing the ingredients and supplying the mixture to the furnace, whether pot or tank, is easily understood, and the necessity appreciated, but the chemistry of fusion or the reactions which occur in the heated furnace are not known in complete detail. Of the nature of the intermediate products that are formed on the application of heat practically nothing is known, and we can only argue back from the end result. A mixture of sand, carbonate of soda and carbonate of lime in known proportions, submitted to considerable heat will undergo changes that can be followed with some exactness. At high temperatures the silica acts like an acid and attacks the carbonate of lime, and probably the carbonate of soda, which heat alone can hardly decompose. The order of the reactions and the conditions that secure technical success are alike uncertain, but the final result is the expulsion of all carbon dioxide except what may be contained in the bubbles trapped in the molten glass, which are removed in the process of "fining." The reactions are further complicated by the introduction of arsenic or of nitrate of soda. How the arsenic acts is very obscure, but the action of the nitrates is apparently to provide a supply of oxygen, which destroys any organic matter present, oxidises the iron, and acts mechanically in expelling the small bubbles of gas, which are too inert to be carried off by the larger air bubbles. If the reactions here are doubtful they become more indistinct when other materials are added to accomplish desired results. We may omit the apparently incongruous insertion of a potato into pot-made glass, probably due in the first place to an accident. In the case of soda-lime glass, however, charcoal or anthracite is introduced with the view of bringing about the rapid decomposition of sulphate of soda, but little is known of the successive steps of the process. To discover the character of the intermediate products, much more experiment, both difficult to conduct and expensive to enter upon, is urgently needed.

The manipulative dexterity of the glass worker does not really enter into the manufacture of glass, and we leave the technical details with regret, for the description of the glass blower's expertness gives an enhanced interest to the volume. The necessity for annealing in all manufactured articles is explained with great care, and will be followed with eagerness. The ingenuity displayed in the production of blown and pressed glass, the formation of sheet glass from blown cylinders, the process of "flashing" and the use of coloured "glazes," all the outcome of many centuries of experience, are handled with the skill of a master and the adroitness of an expert. The details of the various processes are placed before the reader in a picturesque and fascinating manner. For those who want to know the principles that govern the various methods and would follow the manufactured glass from the furnace till it becomes a wineglass or an artificial gem, a paving block to be trodden under foot, or an ornament in a cathedral window, will hardly find a more pleasant guide through the labyrinth of processes, that ingenuity has suggested or science perfected.

Mathematics for Engineers. Part II. By W. N. ROSE, B.Sc.Eng. London: Chapman, Hall and Co., Limited, 1920. [Price 13*s.* 6*d.*]

BY claiming in his preface that his two volumes "embrace all the mathematical work needed by engineers in their practice and by students in all branches of engineering science," the author of the volume under review gratuitously introduces a standard of comparison which, if accepted, would necessarily result in a very unfavourable verdict. Those interested, for instance, in hydrodynamics or in the mathematical theory of elasticity, or in wireless telegraphy, will find not a word on the solution of partial differential equation of the second degree, and those interested in dealing with tabular matter, and in methods of approximate integration and differentiation, will have to seek elsewhere than in the author's treatises an adequate introduction to the calculus of finite differences, and the surveyor will find the author's treatment of the method of least squares far from sufficient for his needs. Indeed, the "normal equations" of Gauss are not even mentioned, and in all the examples chosen there is but a single variable involved. Moreover, we note that the proof given of the form of the probability function is credited to Kelvin instead of Herschell, its true author.

Having made these adverse comments, which are merely the meed due to the author's extravagant claims, the book can be recommended as an excellent introduction to the differential and integral calculus, the methods of exposition being such as to commend themselves to the man who means to use mathematics as a working tool, though we are quite prepared to learn that they excite the horror of the mathematical purist. For our own part we would have gone further than Mr. Rose, and based the subject frankly on the doctrine of infinitesimals of different orders.

The writer uses graphic methods to explain the object of the differential calculus, and the plan has distinct advantages; but certain points in the author's exposition appears open to criticism. Thus he assumes (see Fig. 6 of his treatise) the practicability of differentiating a badly-determined experimental curve, thus repeating the blunder of Professor Karl Pearson when he proposed to determine the stresses in a masonry dam by differentiating an experimentally determined curve, the ordinates of which were, on his own confession, uncertain to the extent of 20 per cent. All engineering students should be warned most emphatically that the differentiation of an experimental curve is legitimate only when the form of the function in question is known from theoretical considerations, or when the curve is exceptionally well determined.

The subject of integration is introduced with the remark that it is "without doubt more difficult to comprehend" than differentiation. Our own experience is precisely the reverse of this, although, of course, it is true that in theory the operation is more difficult to effect. In practice the reverse is often the case since even a very roughly determined experimental curve can generally be integrated with considerable accuracy, whilst its differentiation may be wholly impossible. Both here and in the section on the differential calculus the author includes more theorems than are generally given in elementary works on the calculus, but treats almost exclusively of functions of one independent variable only. The methods of demonstration are excellent from the standpoint of the engineering student, and there are numerous examples and illustrations based on problems which may arise in practice. There is a short section dealing with simple differential equations. Unfortunately, many that arise in practical problems are far from simple, and a caution to the effect that most differential equations cannot be solved in a finite form might save the ambitious student hours of futile labour. The chapter on Harmonic Analysis will be found distinctly useful.

BOOKS RECEIVED.

Organising for Work. By H. L. GANTT. London: George Allen and Unwin, Limited. [Price 5*s.* net.]

Aluminium: Its Manufacture, Manipulation and Marketing. By GEORGE MORTIMER, M.Inst. Met. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Compressed Air Power: A Treatise on the Development and Transmission of Power by Compressed Air. By ALBERT W. DAW and ZACHARIAS W. DAW. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

Union Textile Fabrication. With Numerous Original Diagrams, Sectional Drawings and Photographic Reproductions of Spun and Woven Specimens in the Text. By ROBERTS BEAUMONT, M.Sc., M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

Steam Boiler Construction. Rules of the National Boiler and General Insurance Company, Limited, with Notes on Material, Construction and Design of Steam Boilers and Similar Vessels. By EDWARD G. HILLER, B.Sc., M.I.C.E., M.I.Mech.E. Second edition, revised and enlarged. Manchester: National Boiler and General Insurance Company, Limited. [Price 3*s.* 6*d.* net.]

Electric Lighting. By OLIN JEROME FERGUSON, B.S. in E.E., M.E.E. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 15*s.* net.]

American Shipbuilding Cyclopedia: A Reference Book covering Definitions of Shipbuilding Terms, Basic Design, Hull Specifications, Planning and Estimating, Ships' Rigging and Cargo-Handling Gear, Tables of Displacement of Commodities, Arrangement and Working Drawings of Modern Vessels. Edited by F. B. WEBSTER, assisted by J. L. BATES, S. M. PHILLIPS and A. H. HAAG. New York and London: Simmons-Boardman Publishing Company, 34, Victoria-street, S.W. 1. [Price 3*l.*]

Annual Report and Lectures, Keighley Association of Engineers, 1918–19. Keighley: The Keighley Printers, Limited. [Price 1*s.*]

A Primer of Air Navigation. By W. E. Wimperis, M.A. London: Constable and Co., Limited. [Price 8*s.* 6*d.* net.]

The Westinghouse E-T Air Brake Instruction Pocket Book. By W. W. WOOD. Second edition, revised. New York: The Norman W. Henley Publishing Company. [Price 2 dols. 50 cents.]

Jewish Title to Asia Minor. By RICHARD HAYES MCCARTNEY. Chicago: Fleming H. Revell Company.

The Engines of the Human Body. Being the Substance of Christmas Lectures given at the Royal Institution of Great Britain, Christmas 1916–17. By ARTHUR KEITH, M.D., LL.D., F.R.S. London: Williams and Norgate. [Price 12*s.* 6*d.* net.]

Thermodynamics for Engineers. By J. A. EWING, K.C.B., M.A., LL.D., D.Sc., F.R.S. Cambridge: The University Press. [Price 30*s.* net.]

Motor Lorry Design and Construction. A Handbook of the Latest American Practice. By C. T. SCHAEFER. London: Crosby Lockwood and Son. [Price 18*s.* net.]

Controllers for Electric Motors. By HENRY DUVAL JAMES, B.S., M.E. London: Crosby Lockwood and Sons. [Price 21*s.* net.]

The Identification of Organic Compounds. By G. B. NEAVE, M.A., D.Sc., and I. M. HEILBRON, D.S.O., D.Sc., Ph.D., F.I.C. London: Constable and Co., Limited. [Price 4*s.* 6*d.* net.]

Design and Construction of Heat Engines. By WM. E. NINDE, M.E. New York and London: McGraw-Hill Book Publishing Company, Inc. [Price 36*s.* net.]

The Year Book of the Scientific and Learned Societies of Great Britain and Ireland, 1919. Compiled from Official sources. London: Charles Griffin and Co., Limited. [Price 9*s.* net.]

INDUSTRIAL NOTES.

THE agreement arrived at in the Sheffield strike and to which we referred briefly in our last issue, was dated the 9th inst., and is briefly as follows:—All workmen on strike or lock-out to resume work on the same system of payment and conditions of employment as those which ruled prior to May 29 last. An armistice of six weeks, ending on July 24, is decided upon. The National Amalgamated Union of Enginemen and Firemen, acting by itself and apart from any other union, to submit to the Industrial Court of Arbitration the main question at issue, namely, as to whether the men concerned should be paid by the hour (or week) or by the shift. It is understood that the classes of men concerned are boiler firemen, crane drivers, loco. and engine drivers, shunters, and hammer and press drivers, employed in heavy steel rolling mills, forge and press shops, with the addition of gas-producer men, loco. crane drivers, slingers, stationary engine men and service men attached to the same departments. No victimisation to take place on either side. This agreement was brought about by a Mediation Committee formed by local, neutral trade unions; it was signed by the said committee and by representatives of the employers and of the National Amalgamated Union of Enginemen and Firemen. The Rotherham electricians returned to work following upon the said agreement. The Sheffield strike lasted ten days, and is estimated to have involved a loss of £500,000.

The Minister of Labour is intervening in the gas-workers' dispute, and has invited both sides of the Joint Industrial Council for the industry to meet him for endeavouring to arrive at a settlement. A conference was held in London on Tuesday between the employers and the men, but no agreement was come at.

At the close of a meeting on the 9th inst., of the Executive of the Miners' Federation, Mr. V. Hodges, the secretary, issued the following statement:—"The Executive has had under consideration the question of the relation of wages to the recent increase in the price of coal, and also the question of the high cost of living. It was resolved that the conference should be asked to-morrow (the 10th inst.), to instruct the Executive to examine carefully the data relating to the finances of the coalmining industry which is about to be published by the Coal Controller, with a view to securing an advance in wages for the miners, and that a special day should be allocated to the discussion of the Executive Committee's report during the annual conference of the Federation which is to be held at Leamington, commencing July 6." Mr. Hodges added that the Executive had been assured that the Coal Controller's statement on the finances of the industry would be produced next week. This, he said, was the first time such a statement had been issued under the Limitation of Coal Profits Act. After the meeting on the following day, the following recommendation was issued:—"This Conference instructs the Executive Committee fully to examine the data relating to the finances of the industry about to be published by the Government, with a view to formulating a demand for an advance in wages; a special day to be set aside at the annual conference, which commences at Leamington on July 6, to consider the report of the Executive and determine the amount of the advance."

On Thursday, the 9th inst., the Typographical Association handed in notices to expire in a fortnight, which cover machine-minders and compositors all over the country, excepting London. The demand is for an increase in wages of £1 per week, the employers offering an increase of 10s., which has been found insufficient by the men. The Typographical Association has taken action independently of the Printing and Kindred Trades Federation, which is pursuing its own course, and is conducting its own wages movement. Last Friday, the Federation of Master Printers issued the following announcement:—"Negotiations with the unions connected with the printing trade have been in progress for some time, and last week a provisional agreement was reached with the Printing and Kindred Trades Federation and the employers' organisations whereby increases of 10s. per week for men and 3s. 6d. per week for women would come into effect this week if ratified. The Typographical Association, one of the unions affiliated to the Printing and Kindred Trades Federation, declined to be represented at the conference, and although the same offer was conveyed to its executive the latter recommended its rejection when referring it to a vote of the members. The advice of the executive was followed, and as a result of the vote strike notices have now been tendered throughout the provinces. This action of the Typographical Association is regarded as a breach of its obligations as member of the Joint Industrial Council of the printing industry, one of the clauses in the constitution of which provides that any disputes shall be referred to this council before any aggressive action is taken. London and Scotland are not in the area in which the Typographical Association operates, and will not be affected by the steps taken by this union. Ireland is not included, with the exception of Belfast. The members of the other trade unions in the printing industry, which number over 20, have been strongly advised by the executives to accept the offer made, and there is every prospect of this advice being followed. A special meeting of the Joint Industrial Council has been convened for Tuesday, the 15th inst., in London to consider the unconstitutional action taken by the Typographical Association."

In London, a ballot is taking place on the offer of a 10s. increase above referred to.

At the meeting last Tuesday it was decided to urge upon the Typographical Association and the Employers' Federation to arrange for another conference at which representatives of the Printing and Kindred Trades Federation would be present. Further, the Typographical Association undertook to recommend to its Executive Council the withdrawal of strike notices and the embargo on overtime.

We have received information to the effect that the Twickenham Government Instructional Factory strictly confines its attention to the different branches of the engineering trades; it is an engineering workshop, run on the most modern lines, and with the latest machinery. The men are divided into those who are admitted for a course of 13 weeks in the factory, after which they receive a further 39 weeks in employers' workshops, and those whose period of instructional factory training is usually six months, which may be extended to twelve months, and who are not regarded as improvers until they have completed 18 months' training either in the factory or in employers' workshops. The latter represent the men suitable for training as skilled craftsmen, whether fitters, turners, skilled universal millers, etc.; the former, the semi-skilled workmen. The minor machine operators (or the semi-skilled workmen) learn to operate a single machine, whilst the skilled men have a more thorough and a more general course of training. The selection of the trainers is vested in a Technical Advisory Committee, upon which employers and employees are represented in equal proportions, and this Committee further acts in an advisory capacity on all matters relating to the efficiency of training. The training is carried out on productive lines. The manager (Mr. E. Martin) accepts contracts for his factory in exactly the same way as an ordinary commercial firm. The jobs turned out must pass the usual engineering tests. Most of the contracts accepted by the factory are for the small parts of motor-cars, and the management, in order to get a variety of work for the trainees and avoid repetition, endeavours to secure a large number of small contracts rather than a bulk order for a single line. Some of these contracts involve more than one machine operation. One operation is performed by one trainee and the job is then passed to another trainee for the next operation, and so on.

The utmost possible consideration is given to the men in view of their disabilities, but rightly the factory has no room for the new work-shy and the slacker. The trainees work to the clock; each job has its operation card. Bad time-keeping is dealt with by a reasonable system of deductions. The men realise that training must be taken seriously and understand that these precautions are resorted to in order that conditions of training may be rendered as similar as possible to the conditions in which they will find themselves in the ordinary workshop.

A report for the year 1919, on the commercial and industrial situation of Sweden, prepared by H.M. Consul at Stockholm, states that the question of unemployment was not really serious in Sweden during the war. It was, however, somewhat serious during the first three months of 1919, but by July unemployment had practically ceased, and since then there had been a good demand for labour. The Riksdag passed, in September, the Eight-Hour Bill, limiting the hours of work, with certain exceptions, to 48 per week. This Act came into force on January 1, 1920, and employers were inclined to fear that the decreased working time would mean decreased output and raise still higher the price of Swedish export products, which were already alarmingly high. The miners had requested that a proposal be laid before the 1920 Riksdag limiting the daily work of miners to 6 hours. There was at present a movement towards the so-called industrial democracy, several enterprises in Sweden having interested themselves in the question of co-operation between employers and labour on matters such as the observance of labour laws, disputes, methods of work and introduction of new machinery. The present Government programme included a promise to investigate the measures for such co-operation between employers and workers in industry, as it was intended to give the workers a position which would secure them an influence on the conditions of labour without, however, encroaching on the right of the employer to have the economic management of the enterprise. The Government pointed out that there was no question of a step in the direction of socialisation. There had been heavy rises in wages since 1913, and the average number of days worked during 1918 was 274, as compared with 286 days in 1913. Some of the men's average yearly wages quoted are given as follow: Metal and engineering, 73*l.* in 1913 and 146*l.* in 1918; woodworking, 54*l.* in 1913 and 109*l.* in 1918; building, 86*l.* in 1913 and 142*l.* in 1918; power, light and water installations, 72*l.* in 1913 and 157*l.* in 1918; transport, 67*l.* in 1913 and 151*l.* in 1918.

The report for June of the United Society of Boiler Makers and Iron and Steel Shipbuilders states that the question of manning pneumatic riveting tools had been the subject of consideration between the Shipbuilding Employers' Federation and themselves, and the Union's representatives were of opinion that it was a matter for their members to decide by vote as to the number of men employed in each squad operating the tool. At present it was customary to operate the tool with one riveter, one holder-up and heater, and the question was as to whether or not they should have an additional member in each squad. The Union's pneumatic riveting agreement provided for a reduction on hand rates of 25 per cent. if the work was screwed up ready for riveting, and for a reduction of 15 per cent. if the work was screwed up by the squad. The members who had experience in operating the machine should be best able to judge for or against another member in the squad, and no doubt they would be able to voice their opinions in their branches. There was also the question of employment. If each machine was manned by a full squad this would absorb a considerable number of additional members. On the other hand if the screwing up, which was usually done by older members, was done by the full squad (if that were decided upon) this would reduce very much the means of employment for these members. The suggestion that a full squad should operate the machine had been put to the Employers' Federation, and they advised the Union that on their understanding the present agreement was based upon the squad of one riveter, one holder-up and boy, and as the Union had just renewed a slightly amended agreement on this question it might be necessary to have the matter further considered with them should the members decide that in all cases there must be three of the Union members operating the machine. In the past the Union had had district arrangements for full squads on this machine, but for reasons known to the members operating the machine this measure was far from satisfactory to the members directly concerned, and it had been contended that with three members in the squad it would be necessary to have full hand rates for the work. This would be a difficult claim to obtain from the Employers' Federation. The question was a very serious and important one for the members from many points of view, and realising the difficulties of a general alteration of the customs now existing the Union asked the members to give full consideration before deciding the issue. Votes would be taken at the August monthly meetings.

We are informed that a proposal to demand a further increase of 5*s.* per day in the wages of railwaymen is to be brought before the annual meeting of the National Union of Railwaymen at Belfast, which will open on July 5. The resolution to be submitted is in the following terms: "That in view of the constant increase in the cost of living during the last two years, which increase has in no way been met by corresponding increase in wages, and seeing that 4*l.* 10*s.* per week is the minimum upon which railwaymen can live and keep a family upon with any degree of comfort, and without making any allowance for luxuries, we decide to forward a demand to the Ministry of Transport for an increase of 5*s.* per day for all our adult members employed on railways, and request a reply from the Ministry by July 26; we further decide that in the event of the demand not being conceded by the above date, the general secretary shall arrange for this body to meet on July 27 in order to consider the matter again."

"THE CALEDON WELFARE MAGAZINE."—This is a new works journal, issued by the Caledon Shipbuilding Company, Limited, Dundee. The first number, for June, includes among notices of the social activities of the firm, an article on the ethics of sportsmanship, by Lieut.-Col. E. A. Berrisford, M.C., President of the Oxford University Boating Club, contributions on motor-cycling, athletics, allotments, the effect of mechanical inventions on the working-man, boy-life in China, with two pages devoted specially to women. The magazine is published on behalf of the Caledon Shipbuilding Company, by the Industrial Welfare Society.

"COLLISION DYNAMICS."

To the Editor of Engineering.

Sir,—Tresidder is no new name on us in armour-plate theory, and the captain well knows the importance of cover at any such experimental work, however small the scale.

The statement on page 292 of Canon Moseley's "Illustrations of Mechanics," of the experiment of firing a tallow candle from a musket or shot gun through a barn door, not a taper from a rifle barrel, is interesting for the mechanical details it omits to state. The result depends on the length of the candle, the temperature of the tallow, the material and thickness of a barn door, and the striking velocity, and indirectly on the range.

The triviality of the experiment was brought out, page 711, intentionally, by the contrast with Bertram Hopkinson's method of firing a bullet at a steel rod or plate, as an illustration of the same dynamical principles on a nobler scale.

But it was a challenge to our experimentalist, well known for manual dexterity, and his proper scientific attitude of incredulity to statement, until the actual test had been made of a physical fact, whenever possible.

And there was nothing in the statement of the experiment in "Illustrations of Mechanics" to prepare him for the most striking feature of the result, where he found himself bespattered with tallow from head to foot.

The reverend Canon cannot have performed the experiment himself, or else he must stand convicted as a practical joker.

As for the new law proposed by Captain Tresidder in a statement of words, the quantitative results are implied in the algebraical formulæ of § 23, where the theory is supposed to be verified in a small scale experiment of firing a bullet through a wooden block, suspended as a ballistic pendulum in § 19, or else through some wet clay on the block. In this way we imitate armour plate trials on a small scale; and proceed to argue thence on the laws of mechanical similitude to the result to be expected in actual full size. Here, as elsewhere, it is prudent cover should always be taken, as we see, even in the barn door experiment.

The new law is contained as a corollary on the principle of momentum, and does not require a separate long statement in words. There is a maxim in mediæval science, it goes by the name of Occam's razor: *Entia non sunt multiplicanda prater necessitatem.*

Yours sincerely,

G. Greenhill.

Staple Inn, June 14, 1920.

To the Editor of Engineering.

Sir,—A few weeks ago you kindly inserted a letter of mine about the meaning of "Energy" (see page 490 in your issue of April 9), and now there appears, on page 792, a very interesting example of what I had in mind when I last wrote to you.

Here are parts of two sentences: "The power exerted, being work/time, remains constant," "the power it exerts (that is the energy it expends divided by the time it takes) . . . is constant . . . .";

and I suggest that it would be better to stick to Rankine's definition, viz., "Energy *means* capacity for performing work," and "conservation of energy *means* that the energy exerted is equal to the work performed," than to think of energy as a thing that can be *expended*!

As was said by "No. 5," whom I quoted in my previous letter, "Energy never did anything."

Yours truly,

"Mechanic."

June 12.

"GEAR CUTTING."

To the Editor of Engineering.

Sir,—I have only just noticed in your correspondence column Mr. Roger Schweich's letter regarding the above subject, in your issue of May 21, and in consequence beg to apologise for the delay in replying to his criticism.

With regard to my comparison of the Citroen and Gleason type of spiral bevels, I wish to make it quite clear that my comparison was only intended to apply to rear axle drives and the like, and not to engineering generally.

Dealing with the question of smooth running, where smooth running is the only condition imposed upon the design of the gear, that is, where one is not tied for size and strength, and possibly cost, I quite agree with Mr. Schweich, and in fact I should be one of the first to advocate the double helical type. In the case of a rear axle drive, however, lightness and size consistent with ample strength is of first importance; it is therefore not surprising that the designer resorts to all possible means of eliminating the unnecessary and wasteful.

As I have previously said, the whole object of using helical teeth is to overlap the pitch within the face width of the gear, in order to avoid shock of teeth entering into engagement. Further, in the case of a rear axle drive the face width is not usually made more than one-quarter of the apex distance.

In the case of the Gleason type the desired effect can be obtained with a spiral angle of approximately 30 deg., but in the case of the Citroen type the necessary overlap must be accomplished in approximately one-half of the face width, thus making it necessary to adopt a spiral axle whose tangent is approximately twice that of the Gleason spiral angle. This has the effect of reducing the normal thickness of the tooth considerably, which in turn reduces the strength, and the increased length of tooth only partly compensates for this. It appears therefore necessary to have a larger gear in the case of the double helical gear than in the case of a single helical gear, but there is the disadvantage of the extra thrust load.

With regard to the increased thrust with the single helical bevel gear, it is to be remembered that even with the straight bevel, and also with the double helical, it is necessary to provide means of taking up the thrust load, and usually, due to constructional considerations, it is necessary for this part to be larger than is actually required for the loading (this is borne out by the statement contained in the last paragraph of Mr. Schweich's letter). So that if one has already to provide means of taking up thrust in the straight type and this not loaded to its full capacity, it follows that this part is eminently suitable for taking the extra thrust imposed by the single helical type, even if a slightly larger size is required, but this extra thrust must certainly be taken into account when designing for single helical gears.

In comparison with the two types the point at issue then seems to condense to this: Is it better to put in a larger thrust bearing or larger gears? Full consideration, I think, will lead to the choice of the smallest gear consistent with equal strength, which in my opinion lies with the single helical, especially as this type does give smooth running equal to the double helical.

Yours faithfully,

Bernard Shirley.

39, Linwood-road, Handsworth, Birmingham,
June 4, 1920.

"THE DETERMINATION OF THE LOADS ON CRANE WHEELS."

To the Editor of Engineering.

Sir,—I trust that you will permit me to reply as below to the criticisms advanced by Mr. Padfield in his letter dated June 5, 1920, published on page 792 of your last issue.

In the worked example relating to Fig. 1, it was clearly stated that the results given were based on the assumption that all four wheels were bearing load. It is difficult to conceive that a four-wheeled crane would rest for any appreciable time on two diagonally opposite wheels, as suggested by Mr. Padfield. If, however, there is reason to suspect that through inequalities of the track the crane would bear on only three wheels, the method of finding the wheel loads is given in Fig. 4.

With regard to the portal or underhung type of crane referred to by Mr. Padfield, it would appear that he has overlooked the fact that there are two moments to be considered, the planes of which are respectively parallel and perpendicular to the track. This problem is analogous to that of a very short column eccentrically loaded, and also to the unsymmetrical bending of beams.

In the case of cranes having more than four wheels, it is obvious that the elasticity of the carriage will somewhat affect the distribution of wheel loads. On the other hand it is clearly impossible to obtain expressions for the loads covering all probable departures from the ideal conditions.

The assumptions underlying the expressions (5), (6) and (7) have been stated, and these formulæ are therefore put forward as working rules, having as close a degree of accuracy as is possible in view of the indeterminate nature of the problem. In applying these expressions to any particular example, it is necessary to take account of the extent to which the prevailing conditions agree with the assumptions involved.

Yours faithfully,

E. L. Montagnon.

6, Ashmead-road, St. John's, S.E., June 12, 1920.

MANCHESTER STEAM USERS' ASSOCIATION.

The annual meeting of this association was held at the Offices, 9, Mount-street, Manchester, on Tuesday, June 8, the president, Mr. Harold Lee, J.P., in the chair.

The report stated that at the close of 1919 the total number of boilers under inspection showed a satisfactory increase over the previous year and was the highest on record. The revenue also was fairly well maintained, and, with the exception of that for 1918, also constituted a record.

The gross total of boiler examinations in 1919 was 22,256, and of these 11,331 were "Internal," "Flue" and "Entire." No boiler under inspection and guarantee burst during the year, and the committee were glad to be able to again state that no life had ever been lost by the explosion of a boiler from any cause which the association could or ought to have prevented.

The mishaps from overheating of furnaces showed a reduction in number. Cases of grooving of furnace flanges—a sure sign that the feed water is either sedimentary or greasy, and that the boiler is overworked, were fairly frequent, but these defects were now causing little anxiety, because they could easily be made good by electric welding, which was proving to be extremely useful for repair work.

As a matter of interest it was mentioned that the association's chief engineer had been elected a member of the General Committee of the British Association, and had also had the honour of O.B.E. conferred upon him for services in connection with the war.

The report stated that the operations of the Boiler Explosions Acts, 1882 and 1890, appeared to have been more extensive during 1919, as the number of explosions coming to the association's notice had been much greater than during the past few years. The association had recorded as occurring outside its ranks 37 explosions, killing 18 persons and injuring 33 others. Of these 20, killing 10 persons and injuring 19 others, may be termed boiler explosions "proper," and 17, killing 8 persons and injuring 14 others, may be termed "miscellaneous" explosions from steam vessels of various types. Thirty Board of Trade reports have been issued, four of which dealt with formal investigations. No orders for costs were made in any case.

The chairman, in moving the adoption of the report, referred in appreciative terms to the work of the staff. The object which Sir William Fairbairn and others had in founding the association in 1854 was to prevent explosions by careful periodical inspection, and the committee believed there was as much work to be done and need for the association's existence to-day as ever there was. There should be no such occurrence as a boiler explosion, and inspection was the preventative of accidents, and certainly paid the owner the best in these days of excessive cost of material and fuel. The association did not accept boilers as a "risk," but the main object was, firstly, thoroughly efficient inspection and, secondly, guarantee or insurance against accident.

Explosions, the chairman said, frequently occurred from steam vessels, steam pipes, flues, &c., as well as from boilers, and the members would do well to have these adjuncts to their boilers placed under the association's inspection.

The resolution was seconded by Mr. James S. Addison, director of the Calico Printers' Association, Limited, and was unanimously adopted.

The committee were thanked for their services for the past year and were elected for the coming year, as were also the association's auditors.

One of the members present, Mr. Herbert Bright, of Messrs. John Bright and Brothers, Rochdale, urged that something should be done to secure that when they bought coal they should have some guarantee of quality. Much of the coal coming into works came in without any test whatever, and it would be well if the association could put some pressure on the coal owners to sell the coal according to some standard. Another member suggested that coal should be put upon a standard of calorific value, which was almost the general system in the United States. At present, steam users were powerless, and they had really to burn what in past times, if sent along, would have to be raked out again as of no use, but only absorbing labour and leading to cost in the removal of ashes.

In reply the president said that the times were abnormal, and it was difficult to get anything done, but the matter should receive the attention of the committee when the proper time came. He added, that the association was always prepared to make analyses of fuel if desired by the members.

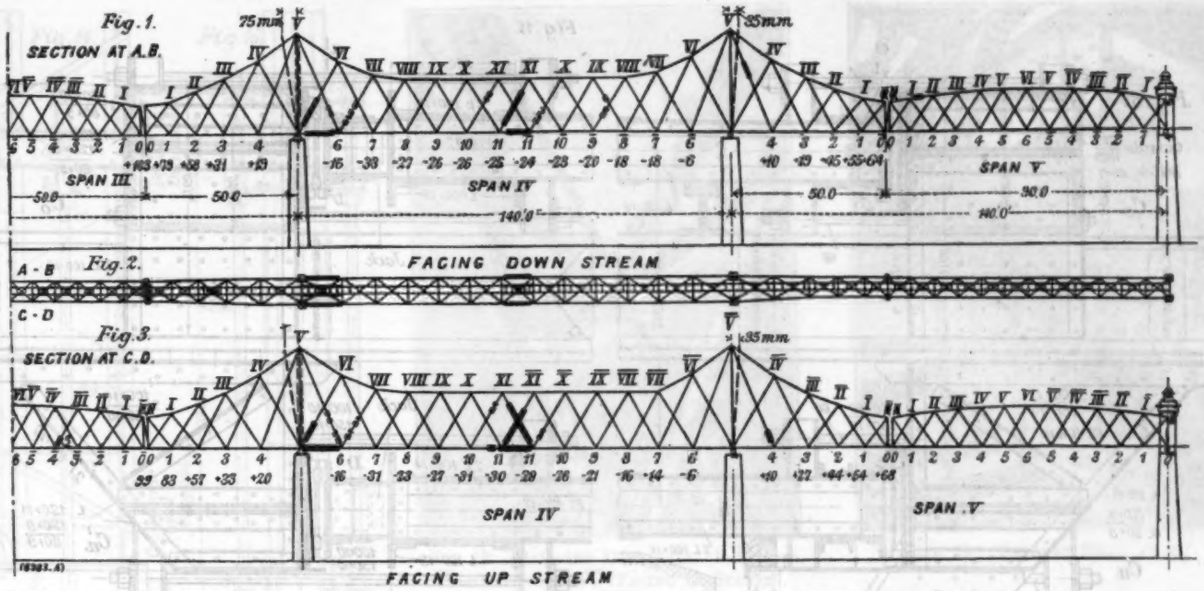
ROYAL METEOROLOGICAL SOCIETY.

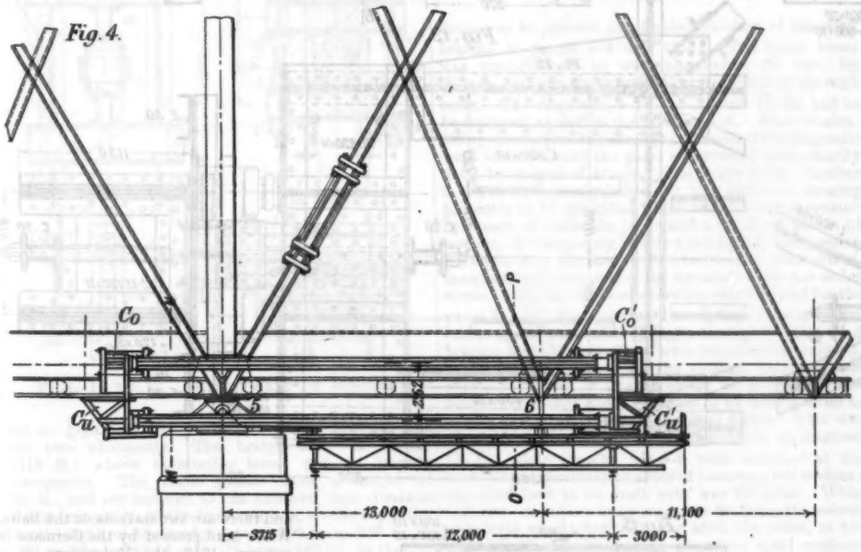
The last monthly meeting of this society for the present session was held on Wednesday, the 16th inst., at the Rooms of the Royal Astronomical Society, Burlington House, Mr. R. H. Hooker, M.A., President, in the chair.

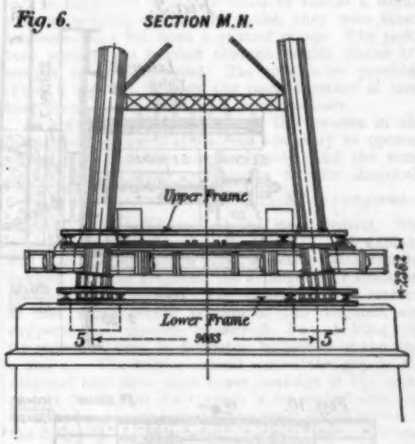
Mr. W. H. Dines, F.R.S., brought forward a paper on "*The Ether Differential Radiometer.*" This instrument has been designed to measure the radiation from the sky after sunset. It consists of two glass test tubes containing air and a few drops of ether, and connected by a glass U-shaped tube containing ether to serve as a pressure gauge. Each test tube is provided with a movable shield which protects it from draughts and allows radiation from one direction only to fall upon it. It is used by first directing radiation from the sky upon one of the test tubes and then radiation from a "black" body at a known temperature. The known temperature is adjusted until the change has no effect upon the pressure gauge, and when this is the case it may be assumed that the radiant energy absorbed by the test tube from the sky is the same as that from the black body whence the radiation from the sky is found by a table. The equivalent radiation temperature of the sky is often below 0 deg. F., and a method is shown by which in this case the sky radiation can be found without the use of freezing mixtures. This is done by compensating the small radiation from the sky by the excess of radiation from a hot body so that neutral effect is obtained. The method of calculation and of making up the results is given.

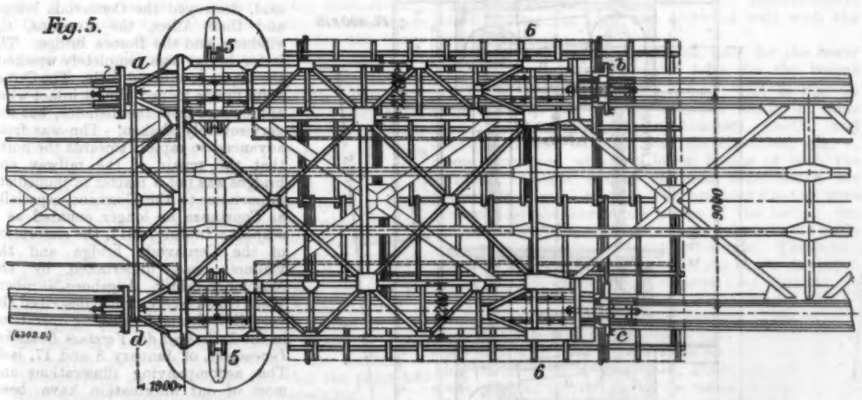
A second paper by Professor S. Chapman, F.R.S., and E. A. Milne, B.A., was read, entitled "*The Composition, Ionisation and Viscosity of the Atmosphere at Great Heights.*" In the stratosphere, owing to the absence of large-scale mixing, the different constituents of the atmosphere must tend to separate out by diffusions, so that the composition varies with the height; in particular well-known calculations have shown that, on the usual assumption of the presence of free hydrogen, the atmosphere above 150 k must consist almost entirely of hydrogen. The authors criticise this assumption; an examination of the evidence renders uncertain the actual existence of this hydrogen atmosphere, and the authors accordingly recalculate the variation of composition with height on the assumption that hydrogen is absent; in this case helium, the next lightest element, is the predominating constituent above 100 k. The results are then used to make an estimate of the depth to which α, β, or γ radiation arriving from an extra-terrestrial source would penetrate the atmosphere. It appears that the range of α particles would extend down to about 80 k—some 20 k below the auroral zone. In the case of β and γ radiation it is found that the maximum absorption, and consequently the maximum ionisation should occur at height of about 50 k and 25 k respectively; in each case the region of appreciable ionisation would be confined to a layer of 35 k thickness, and the unexpected result emerges that the layers would be comparatively sharply defined at their under surfaces, which practically coincide with the positions of the maxima. These estimates have an interesting bearing on recent theories of the existence of ionised layers in the atmosphere. Lastly, attention is directed to the fact that at great heights, though the coefficient of viscosity is little altered, the density is so small that the effective viscosity is very high so that any large-scale motion must die down immediately.

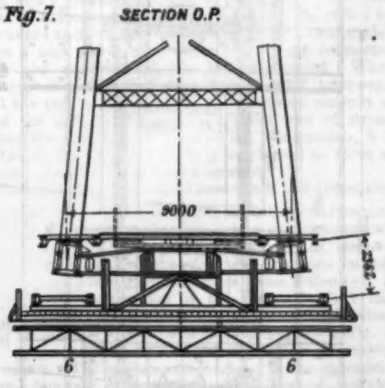
RESTORATION OF THE CERNAVODA-DANUBE BRIDGE.











THE railway from Bucharest, the capital of Rumania, to Constanza, the port of the Dobrudja on the Black Sea, runs nearly due east and crosses the two main arms of the Danube at Fetesti and Cernavoda. At the swampy island known as Balta between the two arms is one of the longest, though not one of the most remarkable of the series of bridges. Both arms of the Danube flow south to north in that part; Fetesti lies on the left bank of the Borcea, the western arm, and Cernavoda on the right bank of the eastern arm, the Danube proper. The series of bridges is 10 miles in length, and consists of the Borcea bridge, the Balta dam and viaducts, and the Danube bridge. The whole was built in the years 1891 to 1896 under the supervision of Mr. Saligny, Director-General of Rumanian State Railways, the contracting firms being Messrs. Schneider, of Creusot, Messrs. Cockerill, and the Compagnie de Fives Lille. The line is all single track,

RESTORATION OF THE CERNAVODA-DANUBE BRIDGE.

Fig. 8.

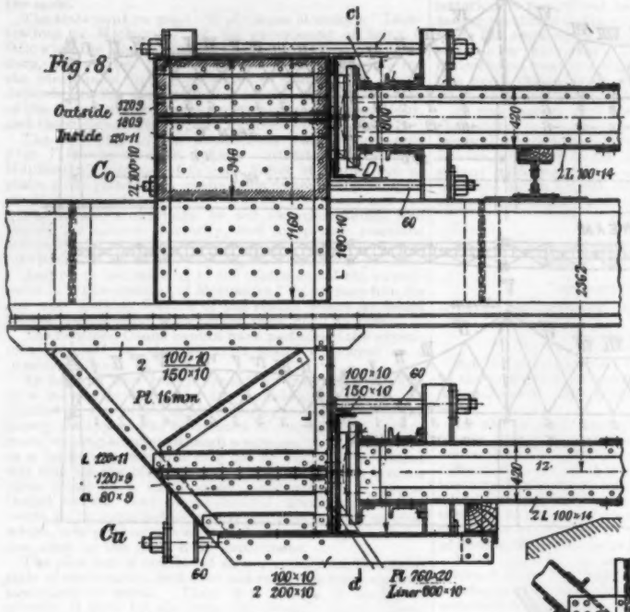


Fig. 11.

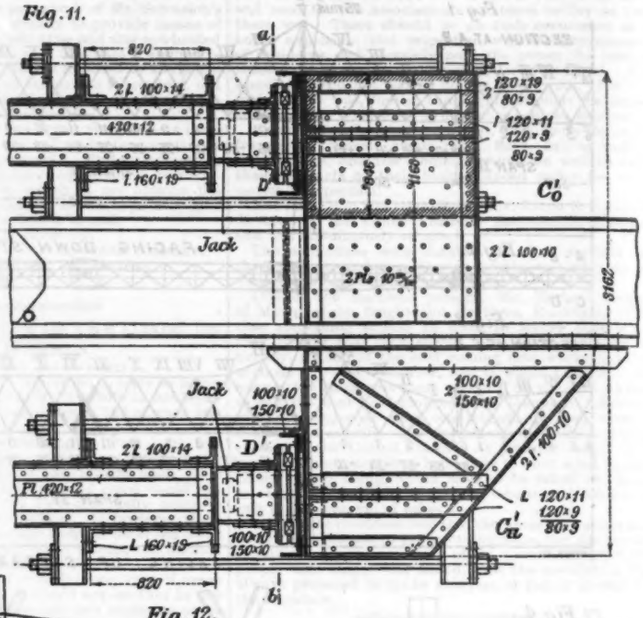


Fig. 9.

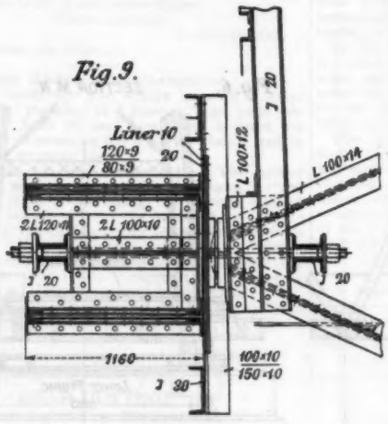


Fig. 12.

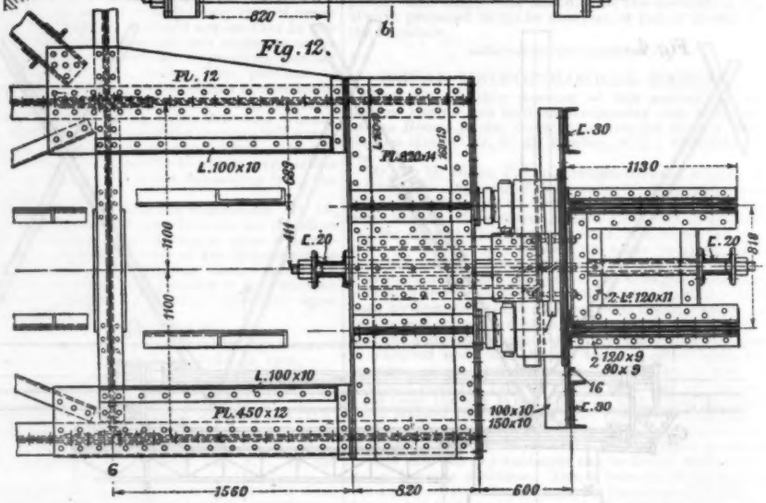


Fig. 10.

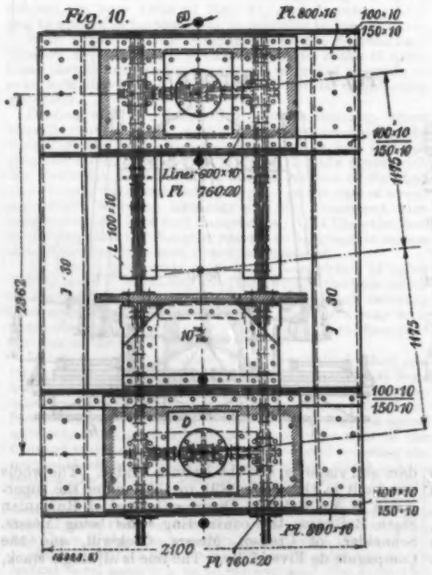
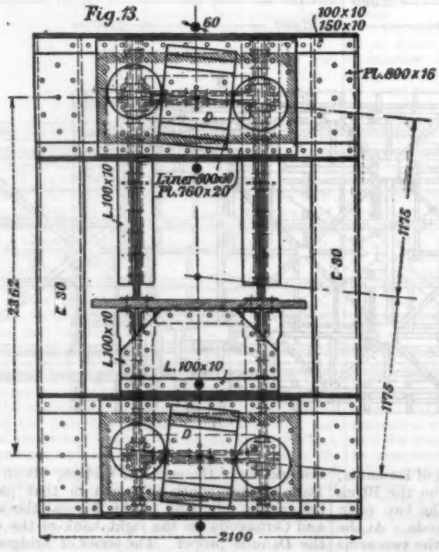


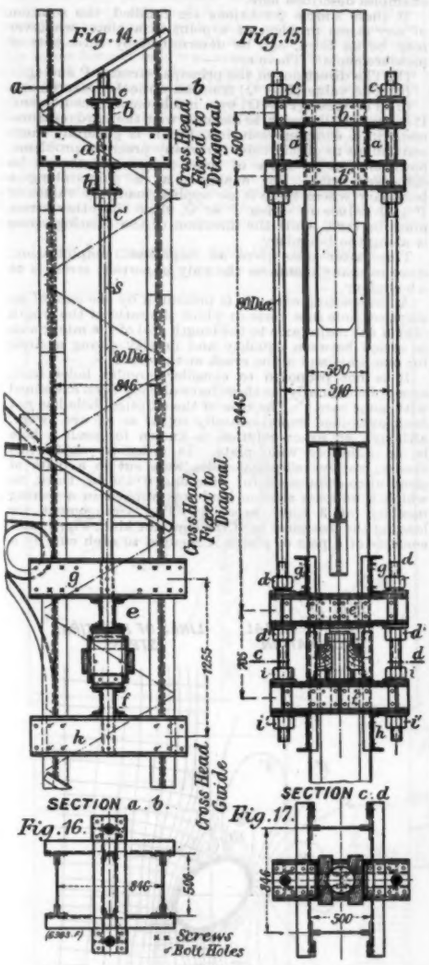
Fig. 13.



and there are two stations on the Balta. When hard pressed by the Germans in autumn, 1916, the Rumanians, it is said, destroyed the Cernavoda bridge, and their Allies, the Russians, the viaducts and the Borcea bridge. The latter bridge was completely wrecked; the viaducts suffered little. The Cernavoda bridge looked almost intact when approached from the distance, but was very severely shaken: The war front advanced so rapidly towards the north that the repair of the railway and bridges was not a matter of immediate importance to the Germans, especially as Constanza no longer counted as a seaport. In July, 1917, the restoration of the Cernavoda bridge and the viaducts was undertaken by the Maschinen-fabrik Augsburg-Nürnberg Werk Gustavsberg, which described the very difficult and interesting operations in the *Zeitschrift des Vereines Deutscher Ingenieure*, of January 3 and 17, last. The accompanying illustrations and most of our information have been obtained from that journal.

Our diagrams, Figs. 1 to 3, show half of the Cernavoda bridge, that is to say, spans IV and V and half of span III; span I is the counterpart of V and span II of IV. The cantilevers, it will be seen, rest on four piers, which are

RESTORATION OF THE CERNAVODA-DANUBE BRIDGE.



FIGS. 14 TO 17. ADJUSTMENT OF STRESSES.

FIG. 18. DAMAGED DIAGONALS 11–$\overline{XI}$ AND $\overline{11}$–XI ON SPAN $\overline{IV}$ (FACING UP-STREAM).

FIG. 19. BRACKET HEAD AT 5.

65 m. high and half embedded in the ground, and on two abutments. The bridge floor is 32 m. (110 ft.) above high-water level, not to impede navigation. The main girders have a height of 33 m., and are inclined to one another, their distance apart being 9 m. at the base and 2 m. at the top; the total length of the bridge is 4 × 140 m. + 190 m. = 750 m., the length of span III being 190 m. In the figures A B represents the girders facing down-stream, C D those facing up-stream; the main dimensions are in metres, the deflections marked under the lower booms are in millimetres, and the other figures are the numbers of the chords. The most serious damage was done in span IV. In the lower boom there were destroyed members 5–6 next to the pier and 11–$\overline{11}$ in the centre; further, in both the girders, the diagonals 5–VI and 11–$\overline{XI}$, and in the C D front XI–$\overline{11}$; thus both the diagonals of one panel were missing. The lower booms were, moreover, distorted deflections of over 100 mm. being observed in the adjoining spans III and V. Span IV itself was so badly weakened that it ought to have collapsed. That it did not, once more shows that statically indeterminate structures may have greater strength than theory ascribes to them. The longitudinal floor girders, the track bed and the wind bracing riveted to the lower boom, as well as the ample cross stiffening, certainly helped to keep the structure on the piers, although these parts were themselves pierced and distorted; the bending of the transverse girders and the fact that the paint had split off many joints indicated heavy straining.

Any disturbance of the structure threatened to cause immediate collapse. Our photograph, Fig. 18, on this page, shows what remained of the diagonals 11–$\overline{XI}$ and $\overline{11}$–XI in front C D; Fig. 19, we mention here, is a photograph of one of the bracket-heads used in repairing the lower boom 5–6 close to the pier. The first thing done was to prevent any further yielding of the wind bracing in panels 5–6 and 11–$\overline{11}$. The lower boom was strengthened by securing timber, 30 mm. by 30 mm., on from above and below, fastened by through bolts. The diagonals 5–VI, 11–$\overline{XI}$ and $\overline{11}$–XI had to be replaced, as well as the member 5–6. After recalculating the stresses, the damaged portions of the diagonals were removed, and the parts substituted preliminarily fixed by means of straps. The lower boom member 5–6 was then strengthened by the elaborate framing presently to be described which was put under tension by means of hydraulic jacks and secured by means of wedges. Subsequently it was fixed by flat bars, which were put on *in situ* and drilled and bolted there simultaneously with the ends of the members while not under stress. A similar mode of operation was adopted for the panel 11–$\overline{IX}$. The structure having thus been rendered stable again, parts of the longitudinal girder and wind bracing could be spared and were temporarily removed, to be replaced later. As the system comprised one redundant chord it was necessary to put one of the temporary chords under a tension of 94 tons in order to adjust the stresses before the final fixing. This was done (by machinery also to be described) on diagonal 11–$\overline{X1}$, while theacks in 5–6 were actuated at the same time sufficiently to allow of loosening the wedges; the total load to be dealt with was 365 tons. When the new members were ready to be fixed the screws and bolts were taken out, one after the other, at the one end, the straps serving as guides until replaced by the permanent new parts. The measurements taken during the load test accorded well with the calculations.

The framing above referred to, used for the lower booms 5–6 and, in a simpler form, for the booms 11–$\overline{11}$, is illustrated in Figs. 4 to 7, and in Fig. 19 which shows one of the bracket heads of this auxiliary structure. These brackets Co–Cu and Co^1–Cu^1, it will be seen from the elevation, Fig. 4, were connected with the lower booms of both the girders; further details of their construction are shown in Figs. 8 to 13. The brackets Cu–Cu^1 were screwed to the horizontal plates of the boom; the brackets Co–Co^1 reached with their webs into the lower boom and were screwed to the boom webs. The lattice framing *a b c d*, which bridges the gap in the destroyed members 5–6, was stretched between Co–Co^1 on the one side and Cu–Cu^1 on the other. The parts *a b* and *d c* were built as parallel lattice girders, 2,200 mm. in height. There was a diagonal in each panel, except at the joint 5 in order to leave room for the post 5–V and for the main girder diagonals; there a small bracket was adopted for connecting the upper members of the framing with the cross-girder of the bridge. For similar reasons two half diagonals (instead of one whole) were put in at joint 6. Beyond 6 the upper framing extending into panel 6–7 were connected by a crosshead supporting the jacks. Within panel 4–5 *a b* and *d c* were cross-connected by a lattice girder, within panel 5–6 by a wind bracing consisting of a lattice structure with crossing diagonals. At *a* and *d* these cross-girders rested against the bracket with the spherically-turned plates D (Figs. 8 to 10). At joint 6 hydraulic jacks were inserted between the framing and the bracket, four altogether (Figs. 11 to 13). The total stress in the lower boom chord 5–6 being 365 tons (in each girder), each jack had to supply 91 tons; in order to ensure a simultaneous working of the four jacks, they were interconnected and fed from a central pump. The jacks bore against the bracket through double plates D^1, wedges being interposed. Tie rods were provided (Figs. 8 and 11) to keep the parts together in case that several jacks should fail simultaneously.

As regards the adjustment of the stresses in the diagonals it was not considered necessary to operate on all the diagonals simultaneously, and the same device was applied successively to the diagonals 5–VI (which is a tension chord), 11–$\overline{XI}$ (a compression member) and $\overline{11}$–XI (in both the main girders). The device, which diagrams, Figs. 14 to 17, will explain, was also used on other parts, together with simpler devices. In our diagrams the arrangements made are for putting on tension. The crosshead *a* is screwed to the upper intact portion of the diagonal, and supports the smaller crossheads *b* b^1, holding the tie rods *s*, 80 mm. in diameter, by means of the nuts *c* and c_1. The rods *s* extend across the gap in the diagonal and have their lower bearings in the crosspiece *e* (with nuts *d* d^1) which is suspended from the crosshead *g*, *g* being bolted to the lower intact portion of the diagonal. As illustrated, the nuts *d* are not in contact with *e* because tension is to be applied. The jack rests on the cross-piece *f* which is fixed to the rods *s* by the nuts *i* and i^1. The crosshead *h* finally is suspended from *f* and serves as a guide, not being connected with the diagonal in the case illustrated. When pressure is put on in the jack, *f* is forced downward and the pull is increased to the calculated amount so that the new parts can be mounted free of stress. When the device is to be used for compression, *h* is bolted to the diagonal whilst *g* is released to serve as guide; the jacks then force *e* upward.

The other repairs involved lesser risks and difficulties. In the panel 11–$\overline{11}$, for instance, the full special framing was not required, bracket heads and compression rods being sufficient to meet the symmetrical stresses. The replacement of the damaged portions of the longitudinal plate girders caused some difficulty; in span V the destruction of the diagonals ⊕–1 had rendered half of the number of the diagonals useless, and an auxiliary displaceable post 0–⊕ (see Fig. 1) had to be erected, and there were other interesting problems. The main causes for delay in the operations were, however, the general difficulties of working during the war, hundreds of miles from the contractors' works, in enemy country where neither materials nor skilled labour were available, and the climatic conditions extreme. The four skilled Germans and the war prisoners, with whom operations were commenced in July, 1917, spent much of their time in hospital and

had to be replaced. Matters improved in autumn, when a dozen mechanics were sent to the spot; the December cold, as severe as the summer heat, interrupted operations. Yet with the aid of a ferry across the Borcea and the repair of the viaducts and the Cernavoda bridge, a kind of railway service could be resumed by February 8. After a train load test of April 2, 1918, conducted on the basis of the original load test, normal traffic was reopened.

THE EFFECTS OF HOLES, CRACKS AND OTHER DISCONTINUITIES IN SHIPS' PLATING.*

By Professor E. G. COKER, D.Sc., F.R.S., and A. L. KIMBALL, Junr., M.E.E., Harvard.

THE present paper is an extension of the subject-matter of two former papers† in the Transactions of the Institution of Naval Architects, in which the effects of various discontinuities were examined to find the alteration in the stress distribution produced thereby, principally in tension members. It confirms, in general, some of the principal results of the mathematical theory of the stress around an elliptical hole in a wide plate, which formed the subject-matter of a paper‡ by Professor C. E. Inglis contributed in 1913. Viewing a crack as the limiting case of an ellipse, in which the minor axis is vanishingly small, it is easy to show, both from calculation and experiment, that a crack inclined to the direction of stress produces a great concentration, which approaches an infinite value. A practical way of reducing the stress intensity is to drill out the ends of the crack, and the experiments described here show what effect this produces, and also the change in stress produced, by forming elliptical cavities at the ends instead of circular holes.

At the date of the earliest of the papers mentioned above, the stress which occurs in deck plating at a hatchway was also examined, but only for the purpose of determining the stress across the weakened principal section, whereas the principal point of interest arises at the change of section of which some measurements are now contributed, to show how great is the stress experienced at the join of the diminished section to the main body of the member.

The experimental methods used have been sufficiently described before, and it is, therefore, only necessary to recall that the complete determination of stress in a plate subjected to loading in its own plane can be completely solved experimentally without reference to any theory of stress distribution, provided it may be assumed that the plate is not so thick as to cause a variation of stress across the section, and for applications to other materials that load systems applied to each edge boundary are in equilibrium separately, as is the case in all the examples described here.

If these simple conditions are fulfilled, the solution of any stress problem at a point in a plate, whatever may be its form, can be determined by three sets of measurements. These are:—

(1) The directions of the principal stresses P and Q.
(2) The value (P − Q) from an optical measurement.
(3) The value (P + Q) by a mechanical measurement.

It is possible, however, to dispense with the third measurement in a complete solution, but it is generally more convenient to obtain this. In many practical problems, however, one or more of these measurements can be dispensed with. For example, at a point along a boundary where there is no applied load, the values of P ± Q reduce to either P or Q, since the other stress must be zero, while the direction of the existing stress is along the boundary.

This latter case gives an important simplification, since in many instances the only important stress is at a boundary.

An interesting example is presented by the case of an elliptical hole in a plate in which the ratio of the length (2a) of the major axis to the length (2b) of the minor axis is varied between equality and infinity giving a circle for one limit and a fine crack at the other.

It is not proposed to consider circular holes here, except incidentally, as these have already been examined with some care.* The case of the elliptical hole has not been examined experimentally so far as we are aware, although an exact solution is known for such a hole in an infinitely wide plate. In order to verify this theory, various elliptical holes were cut in a plate of clear nitro-cellulose 5 in. wide and 0·155 in. thick, to which a uniform tension load was applied in a testing machine of 3 tons' capacity. The arrangement for loading the test piece is of the simplest kind, Fig. 1, and consists of a pair of plates A secured to each end by a number of small pins B, to distribute the pull applied by the machine through centrally-placed pins C. The positions of the holes cut in this plate are indicated approximately in this figure.

In such an arrangement nearly the whole length of the uncut plate should be in pure tension, and this was found to be so, by optical measurements, except for a short distance from the ends.

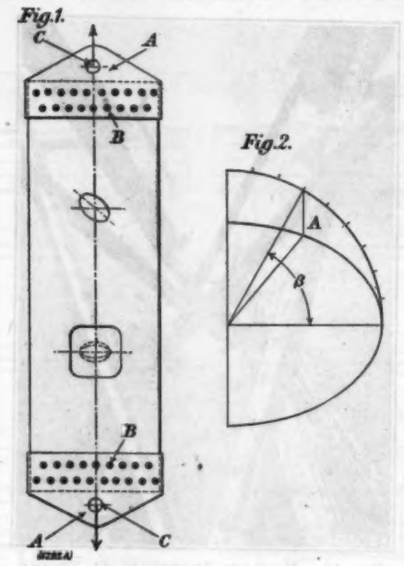


Fig. 1.

Fig. 2.

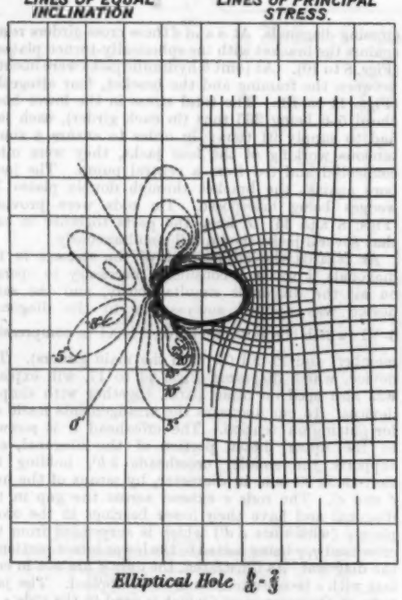


Fig. 3. Elliptical Hole $\frac{b}{a} = \frac{2}{3}$

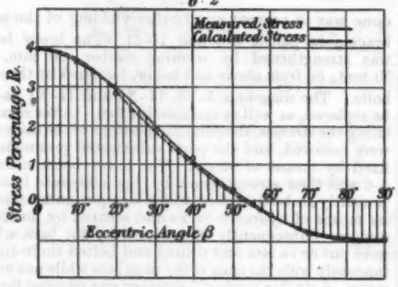


Fig. 4. STRESS AT BOUNDARY OF ELLIPTICAL HOLE. CASE $\frac{a}{b} = \frac{3}{2}$

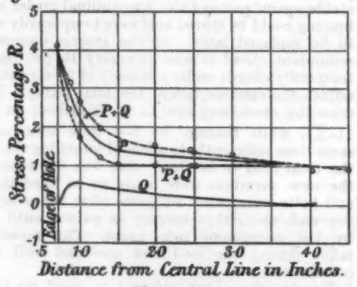


Fig. 5.

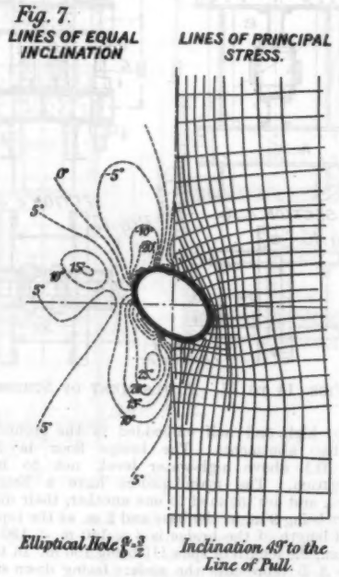


Fig. 7.

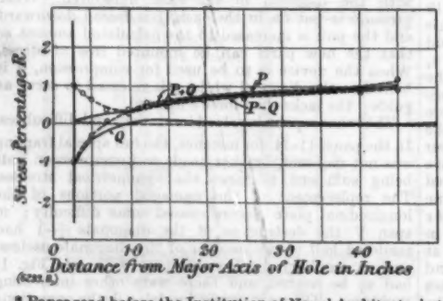


Fig. 6

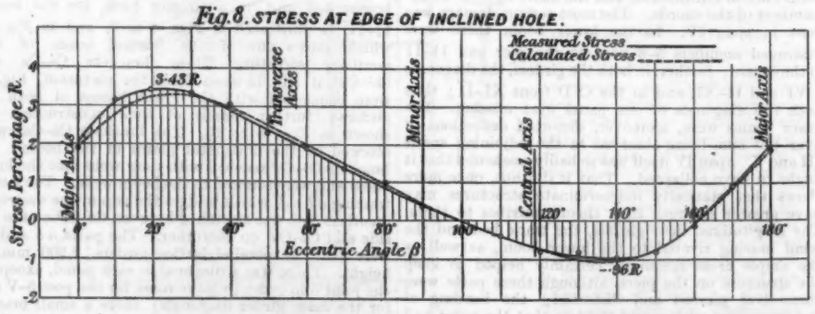


Fig. 8. STRESS AT EDGE OF INCLINED HOLE.

* Paper read before the Institution of Naval Architects, March 25, 1920.

† E. G. Coker: The Determination, by Photo-Elastic Methods, of the Distribution of Stress in Plates of Variable Section, with some Applications to Ships' Plating," Trans. I.N.A., 1911; E. G. Coker and W. A. Scoble: The Distribution of Stress due to a River in a Plate," Trans. I.N.A., 1913.

‡ C. E. Inglis: Stresses in a Plate due to the Presence of Cracks and Sharp Corners," Trans. I.N.A., 1911.

* *Loc. cit., ante.* Column 1.

It was considered sufficient to examine three cases of elliptical holes, and these were selected somewhat arbitrarily by taking an ellipse with a major axis 1·125 in. long perpendicular to the line of pull, and having a minor axis 0·375 in. This hole was subsequently altered to one with major axis 1·2 in., and the minor axis was increased to 0·8 in. In a third example this latter form of hole was intended to have the major axis at 45 deg. to the line of pull, but through an error in cutting out this line was found to have an inclination of 49 deg. to the line of pull, and was therefore somewhat inconvenient for calculation purposes. For convenience of reference in all these cases any point A, Fig. 2, on the boundary of these holes is determined by means of the eccentric angle β for a circle described on the major axis as diameter. It will be convenient to describe the earlier experiments on an elliptical hole athwart the line of pull by reference to the less eccentric one first, although, as mentioned above, the experiments were made in the reverse order to economise skilled workmanship and material. The general features of the stress distribution are apparent at once in the polariscope (Fig. A, page 842), the effect of a pull being to cause an intense stress at the ends of the major axis, and if the elliptical hole reduces to a fine slit, the region around the ends of this latter becomes very much overstressed at even a small load, and shows this on removal of the load by characteristic residual stress effects. It is also to be noticed that the directions of greatest stress intensity away from the hole approach the boundaries at a considerable angle to the axial line, and this leads to the belief that in a plate of narrow width the stress at the outer straight boundaries will be found to reach a maximum at two places equally distant from the line of minimum cross-section. An examination of a plate with an elliptical hole in it of considerable size shows this to be the case and confirms some recent measurements of the effects of moderate-sized circular holes in tension members.* Apparently the stress at the minimum section of this latter member has, in general, maximum values at the inner boundary and minimum values at the outer one. In the elliptical hole the same effect is noticed, and is probably connected with the fact that in such a case the lines of principal stress, having a general direction parallel to the line of pull well away from the hole, curve first one way and then the other as they get farther from the hole, so that there must be a change in stress at the boundary if this latter is only a finite distance away. This effect is noticeable even in the present case, and the lines of principal stress, determined experimentally and shown in Fig. 3, page 840, exhibit this clearly. The lines of equal inclination, from which these curves are derived, are also marked on the left-hand side of the diagram. An examination of the stress at the elliptical boundary shows that its variation is very great. Commencing at the extreme end of the major axis, where the tensile stress is most intense, Fig. 4, page 840, it gradually diminishes to zero at a point having an eccentric angle of 54 deg., and becomes a compression stress, which reaches a maximum at the end of the minor axis.

A comparison of these observed stresses with the calculated values obtained from the appropriate equations of Professor Inglis's paper shows a gratifying agreement, as the figure shows, and affords a proof, if any were needed, that such calculations can be applied to any material which obeys the assumptions on which the mathematical theory of elasticity is based.

The distribution across the minimum section necessitates a complete analysis, which is provided by the curves of Fig. 3, together with the values of $P \pm Q$, expressed in terms of the appropriate mean stress R corresponding to an infinite plate, as shown on Fig. 5. The values of P and Q have been separated from these observations, and are shown by firm lines. It will also be noted that in addition to the great intensity of the tension at the inner point of the boundary there is a perceptible tensional cross stress near the edge, and as the ellipse tends more and more towards a fine horizontal crack, the maximum value of Q increases and also approaches the boundary, although it can never actually reach it in any practical example.

It is interesting to trace the variation of stress along the central axis by observations of the values of $(P \pm Q)$ obtained in a like manner, and these latter are shown in the accompanying Fig. 6, page 840, from which it will be observed that the axial stress is zero at the boundary of the hole and rises gradually to a constant value at a distance of about 2 in. away, while the cross stress is a compression approximately equal in value to the corresponding uniform tension, which rapidly changes to a small tension and ultimately disappears.

The case of the more elliptical hole also bears out these results, and, in fact, the values obtained confirm those described above, so that it is hardly worth referring to them in detail, except to point out that all the experiments for this type of hole agree in showing that the maximum stress is always approximately $(1 + 2\frac{a}{b})$ times the stress corresponding to that of the infinitely wide plate, where a and b are the appropriate values of the axes, and the hole is small.

The case of the elliptical hole inclined to the line of pull presents some interesting features not shown by the former cases. In the first place the maximum stress is not at the ends of either major axis, as the photograph (Fig. B, page 842) shows, but is found at or near the point where the tangent line parallel to the line of pull touches the ellipse. The lines of stress, as may be surmised, only possess a bi-lateral symmetry, as is shown by the experimental determination, Fig. 7, page 840, in which one also observes the tendency of the outer lines to bend outwards at some distance above and below the hole, and not in quite the same way above and below the transverse central plane. They appear, in fact, to indicate maximum stresses at the outer straight sides at unequal distances from the central cross-section, and polariscope observations confirm this.

The stress distribution round the hole has been determined and compared with the theoretical expression of Inglis, and a very fair agreement is found, as Fig. 9, annexed, shows, in which the two are compared by plotting the stresses observed and calculated on a base derived from the eccentric angle β. The stress is found to vary between 3·43 R and − 0·96 R, and is in good agreement with the theoretical expressions. It is also of interest to note that when the stress distribution is examined across the plane perpendicular to the line of pull and passing through the centre of the ellipse, it is found to account for the total pull within 1 per cent.

In the case of two of the ellipses studied, the stresses are determined at points along radial lines 22½ deg. apart, including the longitudinal and transverse sections. The values of P and Q are plotted and contour curves drawn, as shown in Fig. 9 and Fig. 10, annexed. The full-line contours correspond to P magnitudes, and the dotted curves, shown on the left, to those of Q. For the transverse hole five sections are studied, to include one quadrant, and for the inclined ellipse eight sections, covering half of the area, are determined, in order to give the complete stress distribution. For the transverse hole there is quadrantal symmetry, and for the inclined one the symmetry is seen to be bi-lateral, corresponding in each case to the symmetries of the principal stress direction lines shown in Figs 3 and 7, page 840. A noticeable feature shown by the P and Q contour curves is the great rapidity with which extreme values of stress fall off on leaving the edge of the hole. At a distance equal to twice the length of the major axis in any direction from the edge of the hole the values of P and Q have become substantially equal to those which exist at points remote from the hole. It is also to be noticed that where the stress at the edge of the hole is tension, the Q component vanishes, and where it is compression the P component vanishes, the transition points being the four points of zero stress. These points are indicated on Figs. 9 and 10, on this page.

Cracks.—The experiments described above have also an especial interest, since the effect of a fine crack can be estimated from these results. If we consider it as the limiting case of an ellipse, in which the minor axis ultimately vanishes, an infinite stress is produced at the extreme ends for any inclination which does not approach too nearly to the direction of the pull.

Practical men have long been aware of the extreme concentration of stress produced by such cracks, and have provided a well-known remedy for stopping their extension, which is universally used, whether it be for a crack in a steel forging or in a delicate piece of china. It occurred to the authors, however, that the method of drilling circular holes at the ends of a crack might possibly be improved upon. If circular holes of small size are drilled at the ends, the effect is to reduce the stress concentration from some unknown but very large amount to approximately three times the equivalent uniform stress in the uniform plate.* From the preceding results it seems probable that there might be a further reduction of stress if elliptical holes or approximations thereto are drilled at the ends of a crack, with their axes so arranged that the position of maximum stress occurs at the end of the minor axis. In order to test this view a tension member was prepared 1·56 in. wide, in which four fine slits were produced transversely to the line of pull and symmetrically disposed with reference to the axial line. The forms of these slits are shown in the accompanying Fig. 11, but they were actually spaced very much further apart in order to obtain uniform stress conditions in the intervals between them, and the contours of the holes were much larger than necessary for practical requirements in order to permit of a more accurate study of the stress effects produced.

The ends of the first slit A were left exactly of the form produced by a drill of $\frac{1}{16}$ in. diameter, which happened to be available; the ends of the second B were finished with holes of ¼ in. diameter, the third C with vertical slots of ¼ in. length, made by drilling ¼-in. holes tangential to the centre line of the slit and afterwards removing the angles left by the drill. The fourth D, was produced in a similar fashion, and the outer part curved to a radius of 0·22 in. to give an approximately elliptical contour.

The total width of the slit was ⅛ in. in all cases, except for D, and an allowance for the extra stress produced by the increase in the size of the latter is, therefore, made for comparison purposes. The specimen so prepared was then subjected to a load of 100 lb. (corre-

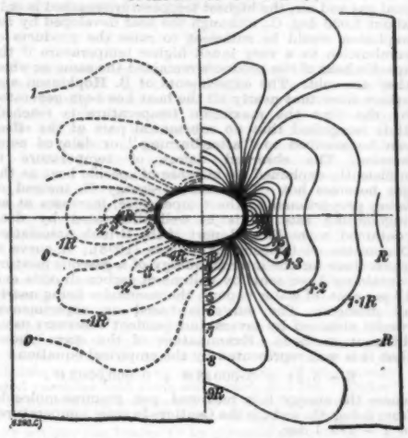


Fig. 9. CONTOUR CURVES OF EQUAL VALUES OF P AND Q.

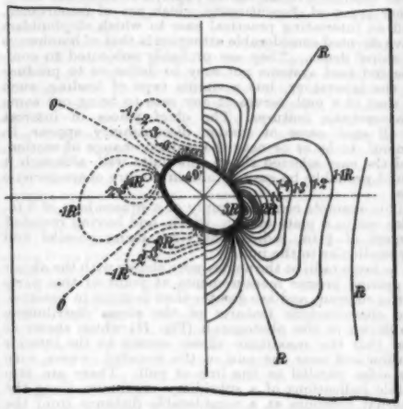


Fig. 10. CONTOUR CURVES OF EQUAL VALUES OF P AND Q.

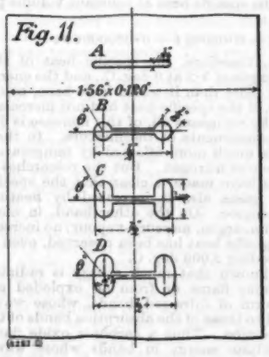


Fig. 11.

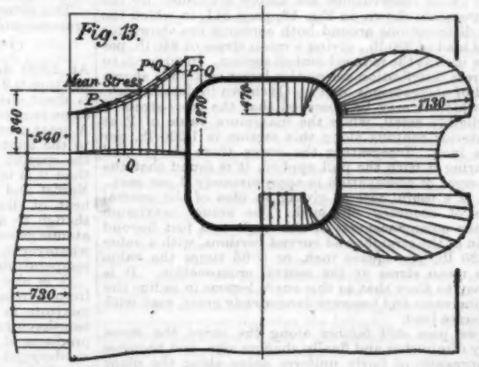


Fig. 13.

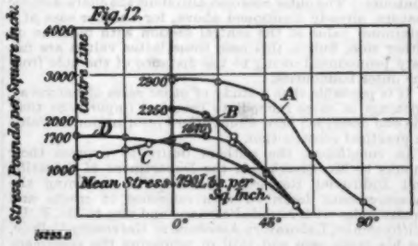


Fig. 12.

* E. G. Coker, K. C. Chakko and Y. Satake: "Photo-Elastic and Strain Measurements of the Effects of Circular Holes on the Distribution of Stress in Tension Members," Transactions of the Institution of Engineers and Shipbuilders in Scotland, November, 1919.

* *Loc. cit., ante.* Column 1

sponding to a mean average stress of 790 lb. per square inch) in a small testing machine and the stresses round the contours determined for a sufficient number of points to make a comparison effective. The values so obtained

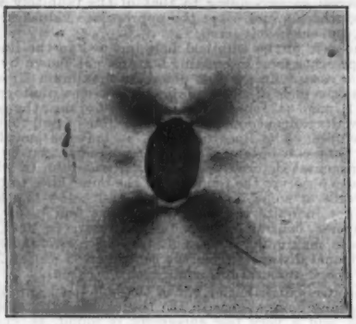


FIG. A. ELLIPTICAL HOLE ATHWART.

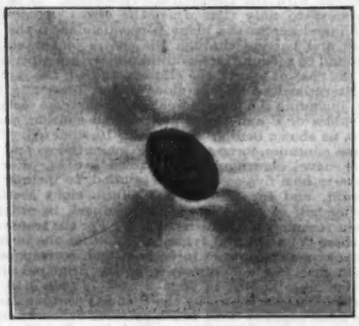


FIG. B. ELLIPTICAL HOLE INCLINED.

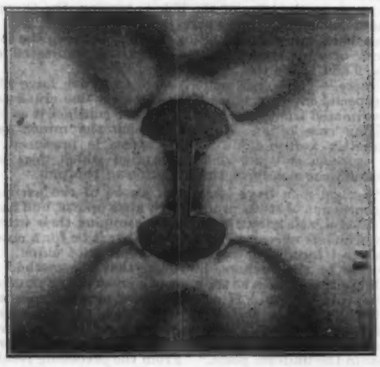


FIG. C. SLIT WITH ELLIPTICAL ENDS.

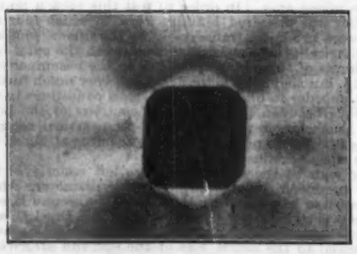


FIG. D. SQUARE HATCHWAY OPENING.

are shown in the accompanying Fig. 12, in which all are compared by aid of angles θ as abscissæ and stress as ordinates, so far as this is possible, and the remaining parts of the contours of C and D by linear measurements along the contour. The distances in the two latter cases are not quite the same, but the difference is not material. The comparison at once shows that for the simple case taken it is possible materially to reduce the high stress caused by a semicircular ending to a crack by drilling out a nearly complete circle, and proves the value of the practical means usually adopted, especially for a hair-line crack, where presumably the stress effect is very great. The substitution of form C effects a still further improvement by lowering the stress intensity from 2,250 lb. to approximately 1,670 lb. per square inch, with a maximum value at an angle of $\theta = 15$ deg. approximately, and a minimum value at the central section of about 1,250 lb. per square inch. The form D, as might be expected, gave a maximum stress at the central line, and as the photograph reproduced in Fig. C shows, and as measured corresponded to a stress of 1,700 lb. per square inch when the extra width was taken into account. Practically there seems little to choose between these two last forms, although the experiment is not decisive one way or the other. Having regard to the measurements on elliptical holes it is possible that form D is actually the best one to adopt if the proper shape of elliptical hole is chosen.

Stresses around Hatchway Openings.—It is unnecessary here to refer particularly to the case of a large circular hole in a tension member of finite width, as these have been examined in an earlier paper, but there are many other types of discontinuity which are of importance, and an interesting practical case to which shipbuilders have devoted considerable attention is that of hatchways in ships' decks. They are probably subjected to complicated load systems not easy to define or to produce in the laboratory, but a simple type of loading, such as that of a pull, serves at any rate to bring out some characteristic features. The chief places of interest in all such cases of sudden discontinuity appear, in general, to be at or near the sudden change of section, and the case selected shows this quite well, although it would probably be easy to obtain a more characteristic one.

This example consists simply of a square hole of 2 in. sides cut in a plate of 5 in. width, and having rounded corners of $\frac{1}{4}$ in. radius, the sides being parallel and perpendicular to the pull.

The large radii at the angles were chosen with the object of getting precise measurements at point of this parts of the contour, and are greater than is usual in practice. The characteristic features of the stress distribution are shown in the photograph (Fig. D) which shows at once that the maximum stress occurs at the interior contour and near the join of the rounded corners, with the sides parallel to the line of pull. There are also visible indications of a subsidiary maximum along the external contours at a considerable distance from the hole. These observations are amply confirmed by the measurements shown on Fig. 13, page 841, in which the stress distributions around both contours are shown for a total load of 390 lb., giving a mean stress of 840 lb. per square inch at the reduced central section. In addition to the stress distribution across this latter section is shown by aid of observations of $(P \pm Q)$ shown in dotted lines, from which it may be observed that the cross-stress Q is negligibly small, while the maximum value of P at the interior contour along this section is 1,290 lb. per square inch. Integrating the curve there shown and comparing it with the pull applied, it is found that the mean error of observation is approximately 3 per cent., which is a useful test as giving an idea of the general degree of accuracy obtained. The actual maximum is at the commencement of the angle and just beyond the join of the straight and curved portions, with a value of 1,730 lb. per square inch, or 2·06 times the value of the mean stress at the central cross-section. It is also easy to show that as this curve lessens in radius the stress increases and becomes dangerously great, even with a moderate load.

As we pass still farther along the curve the stress rapidly diminishes and finally changes sign, and becomes a compression of fairly uniform value along the plane contours. The outer contours also show the characteristic feature, already mentioned above, for another case of a minimum value at the central section with maxima on either side, but in this case these latter values are not very pronounced owing to the distance of the hole from the outer boundaries.

It is probable that a study of other cases of hatchway openings of more immediate practical importance than the one described here would afford information of value in practical construction.

In conclusion, the authors desire to express their thanks to Mr. Chakko, of the Department of Scientific and Industrial Research, for help in obtaining the measurements described with reference to cracks and square holes with rounded corners, and also to Mr. F. H. Withycombe, Laboratory Assistant at University College, for his great care and skill in preparing the specimens and apparatus required.

SODIUM FLUORIDE FOR PRESERVING WOOD.—The highly toxic properties of sodium fluoride have suggested its use for the preservation of wood. It does not attack the wood nor metals, and laboratory tests of this preservative were favourable. In 1914 the United States Forest Products Laboratory started durability tests. They treated sleepers of sap-pine with sodium fluoride, others with zinc chloride or creosote and left some untreated; these sleepers were laid in a mine of a railway company near Birmingham, Alabama. Similar experiments were made on the Baltimore and Ohio Railroad with sleepers of red oak. After five years a good many of the untreated sleepers, both of the pine and the oak, were found badly decayed. In the case of the sap-pine the treatment with sodium fluoride had answered as well as preservation with zinc chloride, though not quite so well as with creosoting; in the case of the red oak comparative tests with creosote were not made.

MOLECULAR ENERGY IN GASES.*

By Sir J. A. EWING, K.C.B., F.R.S.

EXPERIMENTS on the specific heats of gases and on their infra-red emission and absorption have gone a good way towards showing how the molecules take up energy when a gas is heated, and have raised questions as to how far the observed facts may be explained on the basis of "Newtonian dynamics," and what particulars suggest or necessitate a resort to the quantum theory. It may be useful to state some of these questions without attempting categorical answers, which indeed cannot be offered until the physical concepts underlying the quantum theory have become more definite.

It is now established that when diatomic and polyatomic gases are strongly heated the specific heats become notably greater, and that the increase of specific heat is associated with infra-red radiation. Both of these effects are conspicuous when an explosive mixture is fired in a closed combustion vessel or in the cylinder of a gas engine.

In the explosion, for instance, of a rich mixture of coal gas and air, the highest temperature reached is only about 2,000 deg. C., although the heat developed by the explosion would be sufficient to raise the products of combustion to a very much higher temperature if the specific heat of the products remained the same as when they are cold. The experiments of B. Hopkinson and others show that nearly all the heat has been generated by the time the maximum temperature is reached. It is recognised that no substantial part of the effect can be ascribed to "after-burning" or delayed combustion. The observed defect of temperature is sufficiently explained by increase of specific heat as the gas becomes hot. The internal energy E, instead of being proportional to the temperature, increases at an augmenting rate. This is well illustrated by data contained in the First Report of the British Association Committee on Gaseous Explosions (1908). A curve is given there for the internal energy of a gaseous mixture containing 5 per cent. by volume of carbon dioxide and 12 per cent. of water vapour, the remainder being nearly all nitrogen. The curve is based on experimental results obtained by several independent observers using different methods. Examination of the curve shows that it is well represented by the empirical equation:

$$E = 5{\cdot}2t + 0{\cdot}00043t^2 + 0{\cdot}000,0002t^3;$$

where the energy E is reckoned per gramme-molecule from 0 deg. C., and t is the Centigrade scale temperature, or $T - 273{\cdot}1$ deg.

This gives, for the specific heat at constant volume per gramme-molecule:

$$C_v' = 5{\cdot}2 + 0{\cdot}00086t + 0{\cdot}0000006t^2.$$

At 2,000 deg. C., therefore, the specific heat of this mixture is 9·3, as against 5·2 at 0 deg. C., and the energy is about one-third more than it would have been, at the same temperature, if the specific heat had not increased. A great part, but by no means all, of this increase is due to the triatomic constituents of the mixture. In them the specific heat is much more affected by temperature than it is in oxygen or nitrogen. But the researches of Nernst and others have made it clear that the specific heat of diatomic gases also is increased by heating, though to a less degree. On the other hand, in monatomic gases (helium, argon, mercury-vapour) no increase whatever in the specific heat has been observed, even at temperatures exceeding 2,000 deg. C.

It is also well known that much energy is radiated from a non-luminous flame or from an exploded gas mixture, in the form of infra-red bands, whose wavelengths correspond to those of the absorption bands of the products of combustion. Thus a carbonic oxide flame is observed to radiate energy in bands whose wavelengths have their maxima about 2·7 μ, 4·3 μ and 14·7 μ, corresponding to the three conspicuous absorption bands of carbon dioxide.

In any gas, at temperatures such as 2,000 deg. C., the short-period vibrations which produce the lines of the visible spectrum make no more than a negligible contribution to the energy. This is illustrated by the absence of any measurable increase in the specific heat of monatomic gases at high temperatures.

These facts are obviously consistent with what is, I think, the generally accepted view that in any gas the lines of the visible spectrum are due to vibrations within the atom; and that the longer period vibrations which produce the infra-red bands, and do make a substantial addition to the energy of a hot diatomic or polyatomic gas, consist of to-and-fro' movements of the atoms that compose the molecule.

It is well-known that the measured specific heat of a monatomic gas is fully accounted for, on the kinetic theory, by the energy of translation of its molecules, C_v being practically equal to $\frac{3}{2}$ R, C_p to $\frac{5}{2}$ R, and γ to $1\frac{2}{3}$, when the condition as to density is such that the postulates of the kinetic theory approximately apply. In any gas for which these postulates hold, we may write:

$$E = E' + E'' + E'''$$

where E is the whole communicable energy, E′ is the part of it which is due to translation of the molecules, E″ the part due to rotation of the molecules, and E‴ the part due to vibration within the molecules. C_v is of course $d\,E/d\,T$, and E′ is $\frac{3}{2}$ R T.

The fact that in all monatomic gases γ is found to be exactly or very nearly equal to $1\frac{2}{3}$, and to retain that value even when the gas is strongly heated, shows that in such gases E″ as well as E‴ is negligible. In he

* Abstract of an Address delivered to the Royal Society of Edinburgh, by request of the Council, May 3, 1920.

course of its encounters the molecule acquires no rotation, or at least none that contributes appreciably to the energy. Although, according to prevailing modern conceptions of atomic structure, the moment of inertia of a single-atom molecule about any axis through its centre is excessively small, owing to concentration of the mass in the positive nucleus, it must be regarded as finite, and the principle of equipartition might seem to demand that each of the three degrees of freedom of rotation should take up an amount of energy equal to $\frac{1}{2}$ RT. The aid of the quantum theory has been invoked to explain why this does not occur.* According to that explanation the least amount of energy of rotation which a molecule can acquire during an encounter is $h\nu$, where ν is the number of turns per second and h is Planck's constant; hence the least possible speed of rotation ν is given by the equation

$$h\nu_0 = 2\pi^2 \nu_0^2 I,$$

from which

$$\nu_0 = \frac{h}{2\pi^2 I} \qquad \omega_0 = \frac{h}{4\pi^2 I}$$

and the quantum of energy of rotation is

$$\frac{h^2}{2\pi^2 I}$$

In a monatomic molecule the moment of inertia I is excessively small and the quantum is consequently so large as greatly to exceed the whole energy of the striking molecule, with the result that no energy of rotation passes during the encounter. This extension of the theory of quanta to the rotational kinetic energy of a body that is free to revolve in space without constraints seems to me unnecessary. For the forces in and about an atom may be presumed to be such that the atom is dynamically equivalent to a concentrated massive particle surrounded by a massless quasi-elastic envelope or fender. In an encounter the fenders take the blow and prevent the massive nuclei from close approach.† An encounter between two monatomic molecules whose masses are thus protected cannot be expected to communicate any rotational energy, if we make the very natural assumption that the fender does not transmit shearing stress. In that case the stress due to a blow is radial, and energy of translation only is taken up.

Consider next a diatomic gas. The mass of the molecule is made up, we may suppose, of two concentrated particles held some way apart, and the "fender" of the molecule as a whole will have a surface of revolution about the line joining the two particles. Here, again, if we assume the fender to be incapable of transmitting shearing stress, no energy of rotation about that line can be communicated by an encounter, though the molecule is free to take up, and will take up, energy of rotation about any transverse axis. Thus one of its three degrees of rotational freedom is ineffective, the other two are effective, and the principle of equipartition gives the familiar result that, considered as a rigid body, its whole average energy, $E' + E''$, is $\frac{2}{3}$ R T, making $C_v = \frac{2}{3}$ R, $C_p = \frac{5}{3}$ R and $\gamma = 1{\cdot}4$. This is in accordance with the experimental fact that in general (subject to exceptions which will be referred to presently) a diatomic gas does exhibit very nearly these values of C_v, C_p and γ. The slightly greater value of γ which is observed in normal air, &c. (1·402 or so) is readily accounted for by departure from the conditions postulated in the kinetic theory of an ideal gas, which make P V = R T.

In this case also the quantum theory has been called in to explain a result which seems intelligible enough without it. The moment of inertia of a diatomic molecule about the line joining the two centres is of a much smaller order of magnitude than the moment about a transverse axis. It is of an order so small that the quantum of energy $h^2/2\pi^2 I$ with respect to rotation about that line is very large in comparison with the average energy of the blows which other molecules deliver, even when the gas is strongly heated. According to the quantum theory, therefore, energy of rotation about that line would not become established by encounters. About either transverse axis, however, the quantum of energy $h^2/2\pi^2 I$ is far smaller, and this, or a multiple of it, is readily supplied by the blows of other molecules. Hence the sum of E' and E'' should remain equal to $\frac{2}{3}$ R T, at least up to temperatures as high as are reached in experiments on the specific heats of gases. But the same result, as we have seen, follows from more ordinary dynamics.

An apparently stronger case for the application of the quantum theory to the rotation of molecules in a gas is presented in the remarkable fact, discovered by Eucken,‡ that when hydrogen is exposed to extreme cold (but is still a gas) its specific heat falls to a value which indicates that its molecules have ceased to take up energy of rotation. Eucken found that C_v in hydrogen fell from 4·94 per gramme-molecule at 0 deg. C. (approximately $\frac{3}{2}$ R) to about 3·1 when the temperature was reduced below − 200 deg. C. This has been confirmed by independent measurements of C_p,§ and of γ.‖ As the temperature falls C_v approaches a limit of $\frac{3}{2}$ R and γ approaches a limit of $1\frac{2}{3}$, showing that at a temperature of 30 deg. or 40 deg. absolute the molecule of hydrogen takes up energy of translation only, behaving as if it were a single-atom molecule of double mass. On the quantum theory this is accounted for by saying that though the molecule retains its "dumb bell" form its energy quantum with respect to rotation about a transverse axis is sufficiently large to exceed the energy of the blows which it receives at very low temperatures. Thus if we conceive the hydrogen molecule to be made up of a pair of masses, each equal to $1{\cdot}62 \times 10^{-24}$ gr., at points 10^{-8} cm. apart, the moment of inertia I about a transverse axis is $8{\cdot}1 \times 10^{-41}$ and the energy quantum $h^2/2\pi^2 I$ is $2{\cdot}6 \times 10^{-14}$ ergs, when h is taken as $6{\cdot}5 \times 10^{-27}$ erg-seconds. To compare this with the energy that may be delivered by a blow, we have R for any gas equal to $1{\cdot}35 \times 10^{-16}$ per molecule, the gas constant being 1·985 in thermal units per gramme-molecule, and Avogadro's constant being $6{\cdot}16 \times 10^{23}$. Hence the average energy of translation per molecule, $\frac{3}{2}$ R T, is $2{\cdot}02 \times 10^{-16}$ T, which becomes $5{\cdot}5 \times 10^{-14}$ ergs at 0 deg. C., and $0{\cdot}6 \times 10^{-14}$ ergs at 30 deg. absolute. The latter figure is well below the estimated value of the energy quantum. So far as it goes, therefore, the general result of this calculation is in accord with the quantum theory.

It is extremely difficult, however, to believe that a body of the assumed form, free to move and turn in space without constraint, and exposed to entirely casual blows from other like bodies—which may hit it anywhere and at any angle—can refuse to accept angular momentum from such blows except in finite qualities equal to h/π or an integral multiple of h/π.* A solution may conceivably be found in the idea that the molecule is not really free to turn—that there is a constraint to be overcome, an action say, between it and the other due to forces on the electrons. It may be admitted, from the known facts about the absorption and emission of radiant energy, that the other must be regarded as forming part of the dynamical system. But one naturally seeks an escape from the application of the quantum theory to the rotation of the molecules, and the following suggestion is tentatively offered as an alternative. Eucken's result would be explicable if we might suppose that under extreme cold the hydrogen molecule tends to assume a different form, by a coming together of the two atoms which are held apart at ordinary temperatures. Imagine the pair of massive particles to come together, without coalescing, but so close as to constitute what is virtually a single-atom molecule of double mass. The properties of a monatomic gas would then be simulated, and there would be no communicable rotation. The specific heats would then depend only on translation, and their theoretical values would agree with the observed values. If we accept this view it may be conjectured that the paired atoms come together when the rotational speed of the diatomic molecule falls below a certain limit, perhaps like the balls of an unstable centrifugal governor, and remain together until they are forced apart by a violent encounter. There are obvious difficulties in such a hypothesis, both as to the coming together of the atoms and their separation to restore the usual diatomic form to the molecule when the gas is reheated, but they are perhaps less formidable than those that are involved in extending the idea of quanta to the angular momentum of a free body.

A curious point may be noted in passing. If the hypothesis here suggested be valid, it appears likely that there may be hysteresis in the relation of the specific heat to the temperature when hydrogen is cooled to and warmed from a very low temperature. The dynamical conditions that would bring the pair of atoms in a molecule close together are different from those that would set them apart again; the parting would probably require a higher temperature. One might expect, therefore to find the change of structure exhibit hysteresis, resembling that which occurs in the passage of iron from one to another of two allotropic states.

Returning now to the normal action of a diatomic gas such as N_2, O_2, CO or NO, in which the observed specific heat at ordinary temperatures is completely accounted for by molecular movements of translation and rotation, it is clear that any increase of specific heat when the temperature is raised implies that additional energy is then taken up in establishing vibration, and that the principle of equipartition thereby fails. At ordinary temperatures the terms E' and E'' make up substantially all the energy; the vibration term E''', representing to-and-fro movements of the pair of atoms, is generally insignificant. At high temperatures E''' becomes relatively larger, with the effect that the specific heat C_v increases above $\frac{5}{2}$ R, and γ is reduced below 1·4. In the molecules of these gases, energy of vibration, in any amount that is sufficient to affect measurably the specific heat, is produced only by comparatively violent encounters. But in some diatomic gases, notably the vapours of the halogen elements, it is observed that at ordinary or moderate temperatures C_v exceeds $\frac{5}{2}$ R and γ is less than 1·4. There the atoms are heavy and presumably the bonds between the pair are relatively weak, so that vibrations which contribute a substantial part of the whole energy are set up by low-temperature encounters, vibrations of relatively long period being excited at relatively low temperature.

In a triatomic gas the atoms presumably group themselves with the massive particles at the corners of a triangle, and in a polyatomic gas at the corners of a polyhedron. In either case there are clearly three effective freedoms of rotation, and the principle of equipartition applied to them makes E'' equal to $\frac{3}{2}$ R T. Hence in such gases so long as the vibratory energy is negligible we should have $C_v = 3$ R and $\gamma = 1\frac{1}{3}$. The fact that when the specific heat of such gases is measured in the normal state C_v it is found to be greater than 3 R, and γ always less than $1\frac{1}{3}$, means that there is an appreciable amount of energy of vibration, even at ordinary temperatures. This is especially noticeable in polyatomic gases, where the possible modes of to-and-fro vibration of atoms are more numerous. In CO_2 there are, as we saw, three characteristic modes*—one at least of these modes is excited by low-temperature encounters sufficiently to contribute an amount of energy which reduces γ from 1·333 to about 1·30. In polyatomic gases values of γ as low as 1·13 or lower are found at ordinary temperatures.† The increase in specific heat which is produced by heating shows that the various modes of vibration take up a more and more important part of the total energy as the temperature rises. And measurements of the radiation show that in this progressive development of E''' vibrations of long period begin to contribute substantially while the gas is still comparatively cold, whereas those of shorter period begin to contribute only when the gas is more strongly heated.

How does this progression occur? If we accept the quantum theory the answer is at once given by Planck's formula:

$$E'''_\nu = \frac{x}{e^x - 1} \text{ R T},$$

where E'''_ν is that part of the average energy of vibration, per molecule, which is contributed by a mode of vibration whose frequency is ν, and x is $h\nu/\text{R T}$. In a gas whose molecules are capable of more than one mode of vibration the whole vibrational energy E''' would be the sum of as many terms, in the above form, as there are modes. For any given frequency the factor $x/(e^x - 1)$ tends towards the vaue 1 as T is indefinitely increased, but is insignificantly small when T is low.

Plotted in relation to T it gives a curve which closely resembles the typical curve of magnetisation of a ferromagnetic substance under a steadily increasing magnetic force, with its very gradual beginning, its subsequent rapid rise, and its final asymptotic approach to a limiting value.

So little is known as to the mechanism of vibration in the molecules of a gas that one may be less disinclined to apply the quantum theory to the vibrations of the molecules than to their rotations, especially because in dealing with vibrations the energy-quantum involves a frequency which is determined by the nature of the vibrating body.

The Planck formula is undoubtedly in good general agreement with what is known about the specific heat of gases, both as to the effect of vibrations of the infra-red type in contributing to the total energy, and as to the practically negligible effect of those of high frequency. The measured values of the specific heat in gases are scarcely definite enough to supply material for a quantitative comparison between them and the values that are deduced from the formula. But it may be questioned whether even a quantitative agreement would be decisive, for the general type of curve that is given by Planck's formula is found in other physical phenomena—as, for instance, in the phenomena of magnetisation, where the constraint of the molecules resulting from their mutual forces accounts for similar characteristics in the curve. It would be easy, therefore, to base too much on the fact that the observed changes in molecular energy are adequately represented by means of such a curve. On the other hand, it may be pointed out that such a curve is found in the process of magnetisation only because that process results from the action of indivisible units or quanta, namely, the molecular magnets. This consideration suggests that the apparent antagonism between the older dynamics and the quantum theory may not impossibly disappear when the real nature of the electrical or magnetic atomicity which determines the quantum is understood.

Summary.—A review of known facts about the specific heat of gases, at temperatures ranging from low values up to 2,000 deg. C., points to the following conclusions:—

1. The increase in specific heat which is observed to occur in most gases when they are heated is due to the setting up of to-and-fro vibrations of the atoms composing the molecules. The principle of equipartition does not apply to these vibrations.

2. In monatomic gases substantially all the energy, so far as that is communicable, consists of energy of translation. Accordingly the specific heat is sensibly constant, C_v having the value $\frac{3}{2}$ R and γ the value $1\frac{2}{3}$.

3. In diatomic gases, under normal conditions, the energy consists mainly of energy of translation and energy of rotation about axes transverse to the line joining the two atoms. The specific heat C_v is approximately $\frac{5}{2}$ R, and two-fifths of this quantity is accounted for by there being two (and only two) effective degrees of freedom of rotation. The normal value of γ is accordingly $1\frac{2}{3}$. When the gas is cold the energy of vibration is nearly negligible, except in certain gases such as the vapours of the halogen elements, where it forms an appreciable part of the whole energy even at ordinary temperatures. When a diatomic gas is heated the to-and-fro vibration of the atoms comes increasingly into play and contributes a substantial addition to the

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* *E.g.*, in Perrin's *Les Atomes*, Art. 94.

† *Cf.* Perrin (*loc. cit.*). "Quant au rayon de protection, distance des centres au moment du choc, il définit une distance pour laquelle la substance de l'atome exerce une force répulsive énorme sur la substance d'un autre atome . . . En d'autres termes, chaque atome est condensé au centre d'une mince *armure* sphérique, relativement très vaste, qui le protege contre l'approche des autres atomes."

‡ A. Eucken, *Sitzungsb. d.k. Preuss. Akad.*, February, 1912.

§ Scheel and Heuse, *Sitzungsb. d.k. Preuss. Akad.*, January, 1915; *Ann. d. Physik*, 1913, vol. xl, page 473.

‖ M. C. Shields, *Phys. Rev.*, November, 1917.

* Taking h, as the quantum of kinetic energy of rotation, the corresponding quantum of angular momentum is h/π. The theory requires that no blow should communicate angular momentum at all unless it communicates as much as this, whether we regard the indivisible quantum concerned in the operation as so much energy $h\nu$ or as so much "action" h, the dimensions of which are those of angular momentum.

* An interesting paper by Bjerrum (*Verhandl. d. deutsch. Phys. Gesellschaft*, 1914, page 737) suggests various configurations of a CO_2 molecule to give the three observed periods of vibration.

† Capstick, *Phil. Trans.* A., 1895, vol. clxxxvi, page 588.

energy, with the result that the specific heat rises and γ falls below 1⅔.

4. In all gases at all temperatures there is equipartition of energy between each degree of freedom of translation and each effective degree of freedom of rotation.

5. The abnormal behaviour of hydrogen at very low temperatures, discovered by Eucken, may conjecturally be accounted for by supposing a change of molecular structure to occur which deprives the hydrogen molecule of its two normal degrees of freedom of rotation. If such a change of structure occurs it may be expected to exhibit hysteresis in relation to the temperature.

6. In triatomic and polyatomic gases there are three effective degrees of freedom of rotation which, along with the three degrees of freedom of translation, would make C_v equal to 3 R and γ equal to 1⅓ if there were no energy of vibration. But in addition there is in general a considerable amount of energy of vibration, resulting from to-and-fro' movements of the atoms within the molecule, to which the principle of equipartition does not apply. Vibrations of relatively long period become important at relatively low temperatures. This makes the specific heat actually greater than 3 R and γ less than 1⅓, especially at high temperatures when the energy of vibration becomes a large part of the whole energy.

7. It does not appear to be necessary to have recourse to the quantum theory in dealing with molecular rotations in gases: at the same time the observed facts do not conflict with the theory.

8. The general effect of to-and-fro' vibrations of atoms within the molecules of a gas is satisfactorily expressed in terms of the quantum theory. The resemblance which exists between the type of curve given by Planck's theory and the curve of magnetisation of a ferromagnetic substance suggests that if the nature of the atoms and their constraints were better understood the results might admit of interpretation in terms which would not be inconsistent with the older dynamics.

MINING IN NIGERIA.—The Colonial report, No. 1,030, for Nigeria, issued last April, states that 8,434 tons of tin ore were won in 1918. Gold-mining operations had been continued near Minna in the Niger Province, and 1,414·6 ounces of gold had been won. The coal output was 148,214 tons, the greater part of which had been used by the railway and other Government services, the balance being sold to ships visiting Port Harcourt for bunkers and to the Sierra Leone Government.

HEATING MARTIN FURNACES WITH COLD COKE GAS.—Experiments with cold coke-oven gas as fuel for a 30-ton Martin furnace were begun at the Eisen-und Stahlwerk Hoesch in 1913, and the fuel was in 1914 adopted for the three new 100-ton furnaces of the enlarged open-hearth plant. The gas arrives in 700 mm. pipes, from the coke ovens, cold and saturated with moisture. It was first introduced into the furnace through a square brick tuyere which was advantageously replaced by water-cooled wrought-iron tuyeres, 120 mm. in diameter; the latter last a number of heats, and are exchangeable within half an hour. There was some trouble first with explosions, especially after shutting down, caused by the hot air and gases from the furnace entering the mouth of the pipe, the gas not being under pressure; this trouble was cured by a reconstruction of the valves. Some details of the furnace construction were given by F. Springorum, in *Stahl und Eisen* of January 1 last. The gas contains little sulphur and a great deal of hydrogen, both advantageous features. The flame is almost invisible, and the men had to become accustomed to that; afterwards they preferred using this gas to producer gas. When, however, the calorific value of the gas decreased, mainly owing to the dearth of coal and to labour trouble, the material economical advantages of its use vanished, and experiments are now in progress on preheating and enriching the gas.

RECEIVERS FOR SOUND IN WATER.—Professor H. A. Wilson's account, in *The Physical Review* of March last, of an acoustical research on anti-submarine devices, conducted at the Naval Experimental Station, New London, Connecticut, is confined to the theory and does not give information as to actual apparatus. These may be of a very simple kind, however. His receivers for sound in water were Eroca tubes, consisting of a tube closed at the one end, in T fashion, by a shallow circular metal box, or by a small rubber ball or rubber tubing, the other end of the tube leading to the ear of the observer. The resonance frequency of single receivers of this kind depends upon the elasticity and mass of the receiver, but not upon the size of the tube; one single receiver may be able to concentrate into the tube the energy coming from an area 850 times the cross-section of the tube. When two receivers are used, one for each ear, and mounted at the end of a horizontal rod, the direction of the source can be found by turning the rod until the source seems to lie directly in front of the observer. The apparatus was developed by the General Electric Company and used during the war by the United States Navy. The correct position can always be found unless the two receivers are very close to one another, but the best distance apart is half the wave-length in water for the resonance frequency of the receiver. When n receivers, each of cross-section a, are connected by their tubes to a tube of cross-section $n\,a$, and the lengths of the several tubes are such that all the sounds meet in phase the sound may practically all be concentrated in one tube. The arrangement of several receivers in straight line was proposed by Max Mason and adopted by the Navy. On board ship several receivers are fixed in the hull, with their tubes parallel so that the receivers are all at the same distance from the ship.

CATALOGUES.

Name Plates.—A catalogue from Mr. William York, Old Meeting-street, Birmingham, illustrates a considerable variety of work in cast, stamped and etched name plates, punches, brands, stencils, &c.

Petrol Engines.—A periodical publication issued by Messrs. Rolls-Royce, Limited, 15, Conduit-street, London, W., gives some particulars of their aircraft and motor-car engines, and also refers to the opening of large works in the United States.

Cast-Iron Pipes.—A list of cast-iron spigot and socket and flange pipes comes from the Stanton Ironworks Company, Limited, Nottingham. The quantity of each size in stock ready for despatch is clearly shown. Hydraulic pipes, 3 in. in diameter, are also listed.

Electrical Machinery.—Messrs. Higgs Brothers, Sandpits, Birmingham, send an issue of their monthly list of motors and dynamos in stock, and also give particulars of their maintenance scheme for keeping their machines in order in return for a yearly premium.

Stoves.—A number of gas-heated stoves made of sheet-iron and suitable for drying, enamelling and similar purposes, with trolleys and other accessories, are described in a catalogue from Messrs. Hollings and Guest, Thimble Mill-lane, Birmingham.

Road Sign Posts.—The Stanton Iron Works Company, Limited, Nottingham, send a catalogue of standard parts for erecting road sign posts. A cast-iron standard, pocket sleeves for holding the wood arms and cap and screws enable the signs to be set and secured at the precise angle required are included.

Engineering Books.—A neatly and clearly printed catalogue of books on engineering has been issued by Mr. William Bryce, 54, Lothian-street, Edinburgh. The arrangement under subject-matter headings is, of course, rather difficult, and it has been done at least as well as usual.

Electric Lamps.—The British Thomson-Houston Company, Limited, have issued, from their offices at 77, Upper Thames-street, London, E.C. 4, a new edition of their Incandescent Electric Lamp Handbook for the electrical trade, giving commercial and technical data in complete and well-arranged form.

Lathes.—The National Lathe Company, Cincinnati, U.S.A., send a catalogue of heavy-work lathes of 9 in. to 15 in. centres. The lathes are made with single pulley drive or coned pulley drive, and have a variety of attachments, among which are hexagon turrets for mounting on the shears or on the saddle.

Aluminium Working.—Some useful little booklets on the methods of working aluminium have been issued by the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4. They deal separately with sheet, circular and tube work, giving practical information about pressing, spinning, welding, polishing, frosting, colouring, &c.

Waterproofing Concrete.—Building Products, Limited, 44, King's-road, London, S.W. 3, send a catalogue describing a powder for adding to concrete or cement to make a waterproofed mass. It may be used either for ordinary concrete or for cement mixtures used as plasters, these points being fully and clearly explained in the catalogue.

Heat Treatment.—A useful leaflet, by Mr. L. W. Wild, dealing with the transformation ranges of steel, comes from Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1. The author states that the common assumption that the Ac2 transformation takes place at 10 deg. C. above the end of the Ac1 range is not correct generally, and not uniform for all steels.

Concrete.—Several preparations for application to concrete work are described in catalogues received from Messrs. Rowse and Co., 1, Dawson-street, Whitechapel, Liverpool. These preparations include a surface-hardening compound made in grey or red colours, for rendering concrete floors proof against fire, grease and dust, and a mixing compound for making the concrete waterproof and proof against freezing.

Ventilating Plant.—A system of ventilating workshops adopted by several large engineering establishments in this country is illustrated and described at length by the makers of the plant, the Buffalo Forge Company, Limited, 24, Buckingham Gate, London, S.W. 1. The pipes are carried overhead and the system provides for positive removal of dust, fumes and foul air, and also for heating and humidifying.

Boilers.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, send a new catalogue of their Cornish, Lancashire, water tube and other boilers. The fullest range of sizes is made and all auxiliaries and fittings, including economisers, feed heaters, softeners, pumps, superheaters and liquid fuel burners are listed. A special furnace for burning husks and inferior fuels may be fitted to the Cornish boiler.

Pipe Fittings.—Messrs. Crane, Bennett, Limited, 45, Leman-street, London, E. 1, send a very comprehensive catalogue of pipe fittings, pipe fitters' tools and kindred supplies. It is fully and clearly illustrated, and the various sizes and the variations of each article are clearly tabulated. There is a fully detailed index, some useful practical advice on pipe fitting, and a quantity of technical data. It is certainly one of the most complete and useful catalogues of its kind.

Tool Metal.—A tool metal or alloy, which is not called steel on the ground that iron is not amongst its constituents, has been in use in workshops for some time. It is made by the Deloro Smelting and Refining Company, Limited, Ontario, Canada, and 26, Albemarle-street, London, W. 1, and is called "Stellite." The catalogue states that it will retain its cutting edge at a bright red heat and cut at a much higher speed than high-speed steel.

Steam Cranes.—The Bedford Engineering Company, Limited, Bedford, send a catalogue of locomotive, gantry and fixed cranes. The locomotive cranes are suitable for metre, standard or broad gauge lines and all are equipped with vertical boilers. A variety of jibs suitable for contractors' work are fitted. All these cranes are made of standardised parts. The catalogue contains very full and clearly-tabulated particulars, both technical and commercial.

Boiler Mountings.—The catalogue of boiler mountings and valves issued by Messrs. J. Hopkinson and Co., Limited, of Huddersfield, is a volume of 400 pages, handsomely printed and illustrated and strongly bound. The matter is well arranged and indexed. Each fitting is illustrated with all its main variations and parts, and a table of sizes is added in each case. Valves in many different forms, gauges, traps, expansion joints, special pipes, syphons, whistles, thermometers and all packing, fixing and moving gear, are fully represented.

War Record.—The war record book of the United Brassfounders and Engineers, Limited, whose head office is at Cornbrook, Manchester, contains over 70 pages of illustrations and letterpress describing the work done during the war. The work includes the preparation of non-ferrous materials by casting, stamping and extruding methods, as well as the machining and finishing of parts for shells, pumps, valves, gauges and nearly all applications of brass work. The scope for manufacturing methods afforded by the large quantities required for war supplies was fully developed by the company, and the "Record" is a valuable addition to many similar publications mentioned in these notes.

Gas Engines.—The National Gas Engine Company, Limited, Ashton-under-Lyne, have issued a special catalogue of their vertical tandem gas engines with outputs of from 300 brake horse-power to 1,500 brake horse-power. The cylinders are 18 in. and 24 in. in diameter for town gas, but larger diameters are fitted in the same general design when poorer gas, such as blast furnace gas, is to be used. These engines are largely employed for driving dynamos, air compressors and blowers, and one of the illustrations shows three sets of engines, each of 1,500 brake horse-power, installed at an iron and steel works for blowing the blast furnaces. The catalogue gives very complete information as to the construction, erection, operation and uses of these engines.

Marine Machinery.—Messrs. John Birch and Co., Limited, 2, London Wall Buildings, London, E.C. 2, send a copy of a catalogue which they are issuing, for foreign circulation. They offer the parts of hulls and equipment for single and twin-screw steamships, stern wheel and side paddle boats, tugs, cargo and hopper barges, dredgers of various types, yachts, &c., for export. Each vessel is temporarily erected in the country, marked for re-erection, and dismantled for shipment. Steam or oil engines are also supplied, as well as all dock and other machinery and marine equipment required. All, or practically all, are made by Messrs. William Beardmore and Co., Glasgow. The catalogue is priced throughout, with reservation as to changes in cost. The title of the catalogue is "Dockyard Machinery," which may cause some misapprehension, as it deals mainly with ships and marine machinery.

Road Rollers: Erratum.—We regret that in referring, on page 704 *ante*, to a catalogue of road rollers issued by Messrs. Marshall, Sons and Co., Limited, of Gainsborough, we mentioned that winding drums for steam ploughing might be fitted if required. Messrs. Marshall now inform us that the winding drums, when fitted, are used for facilitating the movement of the roller over difficult ground and not in connection with ploughing work.

FOREIGN CREDIT INSURANCE.—Announcement has been made, says *The Iron Age*, New York, of the organisation of a mutual company for the insurance of credits in foreign countries. The new company is to be known as the American Manufacturer's Foreign Credit Insurance Exchange. The purpose will be to supply adequate information on the financial status of foreign merchants and a reasonable safeguard in individual business transactions. Being a company organised on reciprocal lines, the insurance will be written at net cost and not for profit. The organisation of the exchange is the result of several years' search by various State and trade associations, for a ways and means to solve the problem of foreign credits. At the annual meeting of the Foreign Trade Council at Cincinnati three years ago, Mr. George R. Meyercord, first vice-president of the Illinois Manufacturers' Association, and president of the American Manufacturers' Foreign Credit Underwriters, presented a rough plan for the insurance of foreign credits. Since then the foreign trade committee of the Illinois Manufacturers' Association, in conjunction with associations such as the Farmers' Council, has been working to shape a flexible and effective plan to provide such a service to the American manufacturer. The net result is that there has been formed by officials of the Illinois Manufacturers' Association, and with its approval and endorcement, the American Manufacturers' Foreign Credit Insurance Exchange. Full particulars may be obtained from Mr. John M. Glenn, secretary of the Illinois Manufacturers' Association, 76, West Monroe-street, Chicago, U.S.A.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended. Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

139,894. A. C. Stevenson, South Farnborough, and W. S. Smith, South Farnborough. Valve-Operating Gear. (4 *Figs.*) March 14, 1919.—The invention relates to valve-operating gear for internal-combustion engines, and more especially to engines in which a plurality of poppet valves is situated in the cylinder head and the valve-working rockers move in planes containing the axes of the respective valves which may be inclined relatively to each other. A cylinder 9 has four valves 6. A pull rod 7 is connected to a bridge-piece 5 connecting the outer ends of two parallel rockers 10 mounted on a common pivot 11 on a bracket on the cylinder head. A pull rod 8 is connected to the outer end of a third rocker 14 situated

Fig. 1.

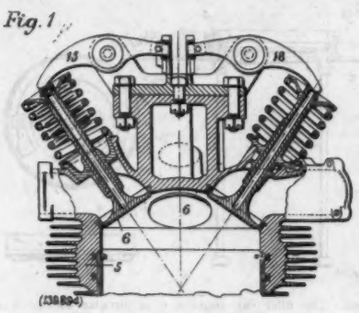
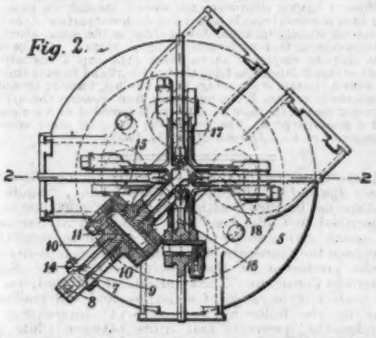
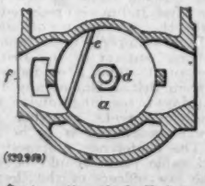


Fig. 2.



between and pivoted on the same fulcrum as the rockers 10. The central rocker 14 is longer than the outer rockers 10 and so shaped as to clear their connection 9. The bracket is placed on the cylinder head so that the inner ends of the rockers 10, 14, are disposed around a point equi-distant from the four valves. The inner ends of the rockers terminate in palms to operate a set of four valve-working rockers 15, 16, 17, 18. The two outer rockers 10 act on the underside of one pair of valve-working rockers 15, 16, whilst the central rocker 14 has its inner end formed sufficiently broad to operate the other pair of valve-working rockers 17, 18, in the same manner. The rockers are mounted on a cruciform bracket which forms four fulcra or supports for the rockers and their outer ends act upon the valve stems. (*Accepted March* 24, 1920.)

139,958. W. G. McCall, Cheadle, and M. L. Glover and Company, Limited, Cheadle. Internal-Combustion Engines. (2 *Figs.*) May 24, 1919.—The invention relates to internal-combustion engines of the two-stroke cycle type in which the charge is admitted to the cylinder at the end of the piston stroke and strikes a baffle provided on the piston so as to deflect it to the top of the cylinder to effect the scavenging of the cylinder of the burnt gases resulting from the previous explosion. In

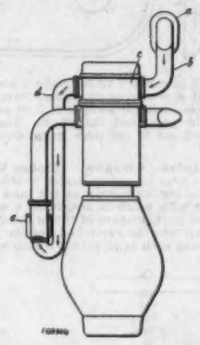


accordance with the invention, the baffle is arranged at an angle which can be adjusted to the line of travel of the charge so that the latter is given a swirling motion round the cylinder, and is not directed immediately to the top of the latter. The top *a* of the piston which carries the deflector *c* is made separate from the piston and secured thereto by the nut *d* so that the position of the deflector with relation to the gases entering the cylinder by the port *f* may be adjusted. (*Sealed.*)

139,980. R. Lessing, London. Absorption Towers. (1 *Fig.*) February 27, 1919.—The invention relates to the hollow cylinders or rings which are arranged with their axes vertical to form a filling for absorption towers, washing towers and distillation columns. According to the invention, such rings are of the form in which there is a diametrical partition *a* which, for purposes of construction, must be complete or nearly complete, but is not in

such connection with the opposite side that gas and liquid cannot pass it or is not at all connected with this opposite side. When the ring is of metal, a strip of the desired width may be fed to a longitudinal slot in the end of a mandril and then wrapped around the mandril; the wrapped strip is then cut, if longer than the periphery of the ring, and the finished ring is removed from the mandril. Each ring has a gap *b* which is advantageous as permitting passage of fluid in a more or less radial direction through the wall of the ring. (*Sealed.*)

139,949. W. Hall, London, and R. Wellesley, Goodmayes. Internal-Combustion Engines. (1 *Fig.*) May 12, 1919.—The invention relates to internal-combustion engines, particularly those used for aircraft, and in which valves of the overhead type are located with their operating mechanism inside a casing which is common to all cylinders in any one row. The invention consists in providing on the engine a scoop *a* connected by a pipe *b* to the section *c* of the engine casing containing the valve stems, guides and springs, and so arranging it that it will encounter the



air as the engine moves along through the atmosphere, and thereby cause a current of air to pass over the said valve stems, guides and springs, an outlet being provided in the said casing to enable the passage of a continual current of the air through it. The said outlet of the engine casing is connected by a pipe *d* to a carburettor *e* so that the air heated by abstracting heat from the valve stems, guides and springs will constitute a source of warm air supply to the carburettor. (*Accepted March* 24, 1920.)

LIFTING AND HAULING APPLIANCES.

139,938. G. D. Hepburn, Glasgow, and R. N. Hepburn, Glasgow. Hoisting Gear. (4 *Figs.*) April 28, 1919.—The invention relates to hoisting gear of the type including a main clutch and a jib-sustaining ratchet and pawl mechanism having interlocking means whereby the pawl and ratchet mechanism is locked in operative position while the main clutch is disengaged or, alternatively, the clutch is locked in operative position so long as the ratchet mechanism is disengaged. The invention consists in the interposition between the main clutch and the jib-sustaining pawl of a rocking tappet which receives movement from the clutch lever and is associated with an extension on the pawl, such tappet being adapted to occupy either of two positions, the first position corresponding to the disengaged position of the clutch and being such that the tappet abuts against an edge of the extension and prevents operation of the pawl, and the second position corresponding to the engaged position of the clutch

Fig. 1.

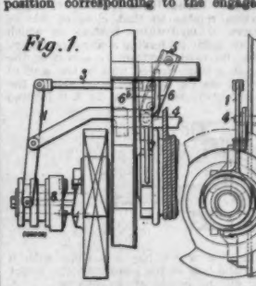
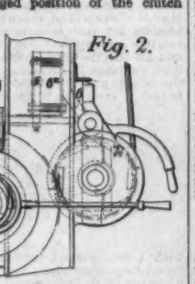
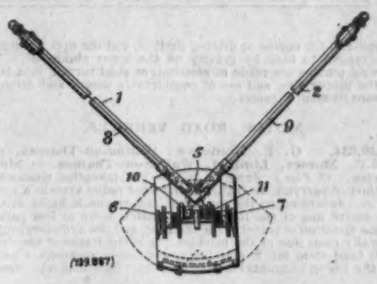


Fig. 2.



and being such that the tappet is in abutting relationship with the lateral face of the extension, and the freedom for the pawl to disengage the ratchet is accompanied by restriction of the movement of the clutch lever. The locking apparatus includes a clutch lever 1 connected by a link 3 to a wiper shaft 4 provided with a tappet 5, the movement of which is a function of the clutch sliding movement. The tappet 5 is formed as a lockbolt co-operable with an extension 6 on the jib-sustaining pawl 7, the arrangement being such that, when the clutch 8 is disengaged, the tappet 5 engages the edge 6a of the extension 6, whereby the pawl is locked in operative position. When the clutch 8 is engaged, the tappet 5 occupies a position clear of the extension 6 and the pawl is free to move into inoperative position under the usual hand control, but the tappet, being in abutting relationship with the lateral face 6b of the extension 6, is only free to move when the pawl is in operative position. The clutch lever is thus locked against movement into the disengaged position as soon as the pawl is disengaged from the ratchet. (*Sealed.*)

139,887. J. Melland-Smith, London. Crane. (3 *Figs.*) March 10, 1919.—The invention relates to a form of double jib crane of that type in which the jibs are simultaneously movable on the same axis, and have their chains or cables so arranged that whilst one is being wound on a drum or the like the other is being unwound. According to the invention, the two jibs are set at about an angle of 90 deg. in relation to each other, are mounted upon the same vertical axis, and also may be independently mounted on horizontal axes so that whilst they move horizontally in equal and simultaneous manner they may rise and fall independently. The crane has two jibs 1 and 2 mounted



upon a rotatable table under which are ball bearings on the bed frame. 5 is a centre column or stay. The table carries bearings which support two drums 6 and 7 fixed to the same shaft. These two drums rotate with the shaft and wind or unwind the chains 8 and 9 of the jibs 1 and 2 respectively, according to the direction of rotation of the shaft. Small drums 10 and 11 are provided and on these the chains for raising and lowering the jibs are wound. In operation one of the chains is wound on to its drum from the underside and the other chain is wound on to its drum on the upper side with the result that because the drums are fixed to the same shaft and simultaneously rotate in the same direction, one of the chains is lowered whilst the other is raised. (*Accepted March* 24, 1920.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

140,034. W. A. Pratt, Coventry. Lubricators. (2 *Figs.*) November 20, 1919.—The invention relates to lubricators for use with, and mounted upon revolving pulleys and other revolving elements. According to the invention, the oil is fed through a radial tube of small bore which projects into a conical cap containing the oil. The oil which is thrown outwards by centrifugal action travels inwards along the tube to the bearing, if the end of the tube is close to the end of the conical cap. This effect is enhanced if the end of the tube is flared and the inside of the cap opposite thereto is provided with a projection. The lubricator body consists of two parts, a base A and a cap A^2 with a coned or domed interior. The cap screws on to an externally screw-threaded flange A^3 formed around the base A, and is there secured by a spring locking ring. To mount the lubricator on the loose pulley B, the base A is provided with a concentrically disposed screw-threaded boss A^4 on its outer end

Fig. 1.

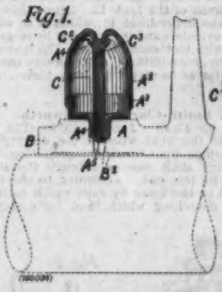


Fig. 2.

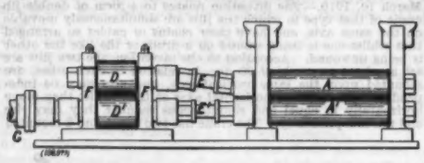
face. Extending into this boss A^4 from the interior of the lubricator is the feed-tube C^4 through which the lubricant is conveyed to the bearing surfaces by way of the passage A^5 in the end of the boss A^4, and by the usual oil ways B^2 in the pulley hub. The position of the lubricator on the pulley is such that the tube C is radially disposed to the pulley axis, whereby its mouth is directed radially outward. The outer end of the tube C closely approaches the apex of the cap A^2, and is flared to form a cup C^5. The oil passage C^3 connecting the interior of the cup with the interior of the tube C is of a relatively small bore, the size of which is dependent upon the rate at which the lubricant is to be fed to the bearing surfaces. Opposite to the mouth of the cup C^5, and at the apex of the cap A^2, is a projection A^6 which extends into the cup, leaving a narrow space between their adjacent surfaces. Thus the projection forms a guide to lead the lubricant from the coned sides of the cap into the cup C^5. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

139,837. P. R. Kuehnrich, Sheffield. High-Speed Tool Steel. November 11, 1918.—The invention relates to high-speed tool steel of the type in which the original iron-tungsten-chromium alloy is replaced by an iron-molybdenum-chromium alloy. According to the invention, high-speed steel is produced by adding to the iron-molybdenum-chromium base a minimum amount of 4 per cent. of cobalt and by varying the amount of cobalt according to the amount of molybdenum used; that is to say, the amount of cobalt is increased when the molybdenum content is made greater than 4 per cent. A typical and preferred composition is as follows: Carbon, 0·5 per cent.; molybdenum, 6 per cent.; chromium, 4 per cent.; cobalt, 6 per cent.; the remainder being as usual, principally iron. In some cases a small proportion of vanadium, titanium or uranium may be added. (*Accepted March* 24, 1920.)

138,971. T. B. Rogerson, Glasgow. Rolling Mills. (2 *Figs.*) January 23, 1919.—The object of the invention is to dispense with the usual expensive helical pinions employed in iron or steel cogging and rolling mills, and to provide an improved friction drive in lieu thereof. A, A^1, are the roughing rolls

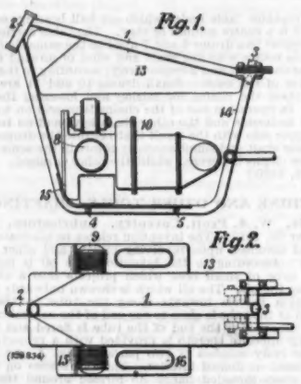
turnably supported in housings fixed on a suitable base. The rolls A, A1, are driven by toothless friction pinions D, D1, through coupling spindles E, E1, the pinions being turnably supported one above the other in housings F, F. The lower pinion D1 is



coupled to the engine or driving shaft G, and the upper pinion D is arranged to bear by gravity on the lower pinion D1. The driving pinions are made of cast-iron or steel turned in a lathe to the proper size, and are of considerable weight and drive by surface friction. (*Sealed.*)

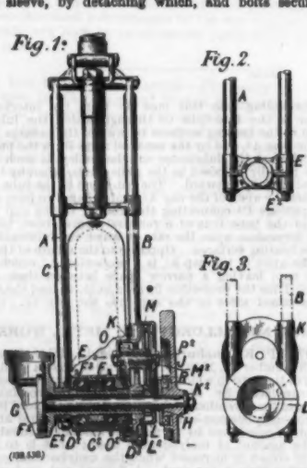
MOTOR ROAD VEHICLES.

139,834. G. E. Bradshaw, Walton-on-Thames, and A.B.C. Motors, Limited, Walton-on-Thames. Motor Cycles. (3 *Figs.*) June 12, 1918.—The invention relates to a method of carrying an engine of the fixed radial type in a motor cycle. According to the invention, the engine is fitted so that the centre line of the rotary crankshaft is more or less parallel to the direction of travel of the machine, and the cylinders project laterally each side of the machine. 1 is the frame of the cycle, with head stem lug 2, seat lugs 3, and cross members 4 and 5 on the lower horizontal frame member. The magneto, crank-



case, cylinders 8 and 9, gear-box, transmission to driving pulley and driving pulley are referred to as the power unit 10. To the four lower edges of the petrol tank 13 are attached four shields, of which 14 is the rear shield. The front shield is a downward continuation of the front of the tank 13. These shields extend downwards to meet the undershield 15, which is as wide as the extreme width of the cylinders and is supported by cross-members 4 and 5 and is fitted with footboards 16, 16. The undershield 15 is turned up in front to give additional protection to the cylinders 8 and 9, but not so far as to divert air from them. (*Accepted March* 24, 1920.)

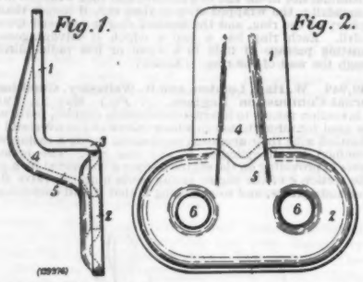
136,536 G. T. Smith-Clarke, Kenilworth. Engine-Driven Scooters. (3 *Figs.*) June 4, 1919.—The invention relates to scooters of the kind wherein the driving wheel is supported upon bearings upon a sleeve projecting from the crank-case, the driving shaft passing through the sleeve and having a flywheel at its free end. According to the invention, the sleeve is held up to the forks by caps which surround and grip the sleeve, by detaching which, and bolts securing the



crank-case to one side of the forks, the engine and wheel can be lowered free of the forks and then be separated from one another. The fork comprises a pair of tubes A and B, one pair on each side of the wheel C. The tubes A on the engine side terminate in a pair of bolts upon which the upper cap E^2 is threaded. The lower cap E^2 is also fitted on these bolts and is secured by nuts D^2. The caps grip the sleeve F, on the engine crank-case F^2, lying between a collar F^3 on the sleeve and the side of the crank-case F^4. The bearings C^2 of the road wheel are carried upon the outside of the sleeve F, and the crankshaft G in bearings upon the inside thereof, and the crankshaft projects slightly from the sleeve to carry a pinion H and flywheel J beyond the end of the sleeve. The pinion H lies within the gear-box. The fork tubes B on this side also terminate in bolts and upon these are threaded the gear-box, which is in two parts K and L. Each part is formed with half a cap K^2 and L^2, and these cap portions grip the end of the sleeve F, being secured by nuts D^3. The crankshaft pinion H gears with a wheel M running free with the lay shaft M^2, which shaft gears by gear wheels O, O^2, on to the road wheel hub C^2. To insert the lay shaft and its gears M and O, an aperture is provided in the outer wall of the gear-box, and the shaft may revolve upon a bolt P passing across the gear-box and serving to hold the cover R for this aperture. Thus the bolt may have a nut P^2 lying on the outer side of this cover. (*Sealed.*)

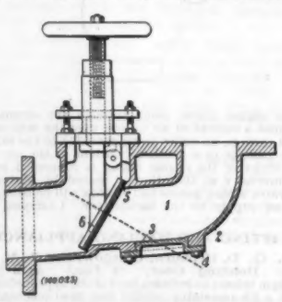
SHIPS AND NAUTICAL APPLIANCES.

139,976. D. A. Brown, Glasgow. Hatch Cleat. (3 *Figs.*) June 12, 1919.—The invention relates to hatch cleats of the type comprising a palm, a cranked upstanding limb for engagement with the usual wedge and a rib extending from the palm to the upstanding limb. The invention consists in a hatch cleat produced by the process of pressing, the cleat comprising an upstand-



ing limb 1 cranked in relation to the palm 2 and formed at the corners 3 with a rib 4 pressed or swaged up from the body of the sheet, the palm being suitably swaged at 5 to afford strength at the junction of the palm and the crank. The requisite rivet holes 6 are punched out of the sheet metal during the pressing process. (*Sealed.*)

140,023. J. Lipton, Glasgow. Storm Valve. (1 *Fig.*) October 22, 1919.—This invention relates to storm valves. The invention resides in the disposition at the inlet side of a storm valve of an orifice with which is associated a removable cover, the dimensions and configuration of the orifice being such as to permit the insertion into the valve body of the driving bar of a facing tool, and being such as to permit convenient access to the



soil pipe for cleaning purposes. There is formed on the inlet side 1 of the valve body 2 an orifice 3 provided with a removable cover 4 and taking the form of an elongated slot permitting the insertion at the requisite angle of the driving bar of a facing tool engageable with the valve seat 5. On removal of the cover 4, convenient access may be gained to the soil pipe through the orifice 3, the clack valve 6, if desired, being closed. (*Sealed.*)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

139,945. E. Green and Sons, Limited, Wakefield, and G. E. Tansley, Wakefield. Hand-Hole Door. (2 *Figs.*) May 6, 1919.—The invention relates to that class of lids of headers for fuel economisers or feed-water heaters in which two lids are employed, viz., an inside lid having a coned periphery and an outside dome-shaped lid held together by a bolt or the like, the inner lid engaging in a cone-shaped hole in the wall of the header and the outside lid seating against the outside of the header. According to the invention, the internal lid A is formed

with a cone-shaped periphery B which has a seating with a coned-shaped periphery C of the hole in the header D, the larger diameter of the hole being on the inside of the header D. A screw-threaded hole E is provided in the centre of the lid. The external lid F is formed somewhat domed shaped with a faced boss G on the centre of the top of the dome through which a clearance hole H is formed, the bottom edge I and portion of the periphery being also faced to form a joint. In connection with these lids A, F, the hole and lids are constructed smaller in diameter than is usual and form a countersunk portion or ledge K on the outside of the hole into which the external lid F can be positioned. (*Accepted March* 24, 1920.)

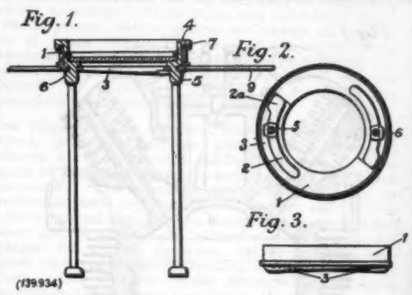
TEXTILE MACHINERY.

139,931. D. O. Jones, Yeadon, and B. Boothman, Todmorden. Bobbins. (1 *Fig.*) April 22, 1919.—The invention relates to a vibrating or non-sloughing bobbin for use in shuttles of looms for weaving, wherein the spring is entirely enclosed and secured within the nose end of the bobbin itself, the spindle passing loosely through the spring, and the terminal button of the spindle being freely slidable within the end of the bobbin. The bobbin is made with its nose end A separate from the body B, the two parts being connected by a tapered socket joint C. The shuttle spindle D is of ordinary construction, but its outer end passes loosely through a short spiral spring E which is fitted within the nose end A of the bobbin, this spring E abutting at its

outer end against the terminal button F of the spindle, and at its inner end against the end bobbin body B. The terminal button F of the spindle is of a reduced diameter so as to be freely slidable within the end of the bobbin, and the spiral spring E is prevented from displacement in an outward direction by means of an enlargement E^1 at its inner end abutting against an internal shoulder G within the nose end A of the bobbin. (*Accepted March* 24, 1920.)

MISCELLANEOUS.

139,934. A. Allbutt, Birmingham. Filler Caps of Petrol Vessels. (3 *Figs.*) April 26, 1919.—The invention relates to filler caps of petrol vessels and has for its object to provide a simple closure. The invention comprises a filler cap in which the socket or seat member is furnished with circumferential slots in its base or flange, the underside of the slotted portions being inclined whilst the cap has depending adjunct shouldered studs or lugs adapted to pass through and traverse along the said slots with the shouldered part riding under the inclined faces of the slotted portions thus drawing the cap tightly and securely on



its seat. The filler cap consists of a circular socket or seat member 1 having circumferential slots 2 through its base, the end 2a of the slots being enlarged and the lower surface of the base therefrom slightly inclining downwardly or the metal about the slots thickening thereby forming wedge portions 3. One or more slots may be employed as required. The cap 4 has adjunct studs or lugs 5 depending from the body part and passing through the slots 2, the said studs or lugs being swollen, forming shoulders. These studs or lugs 5 are prevented from passing through the narrower part of the slots 2. The cap is provided with a washer 7 and a glass cover 8. The top of the petrol or other vessel is represented at 9. (*Accepted March* 24, 1920.)

ITALO-CHILEAN TRADE.—According to *The Board of Trade Journal*, the formation of a company, "Sindicato Italiano del Pacifico," with a capital of 20,000,000 liras, subscribed in Chile, has been announced at Santiago. It has an option to increase that capital to 40,000,000 liras once the shares are offered in Italy to companies and banks interested in the development of the South American Continent. The syndicate, it is stated, has set for itself a large range of activities, and will gradually take up the following business: (1) Interchange of merchandise, products and fruits between Chile and foreign countries, principally Italy. (2) Industrial mineral, constructional undertakings; the importation of machinery and technical materials. (3) Administration, purchase and sale, hypothecation of property, belonging particularly to persons residing in Chile or Italy; agencies and general commission business.

WEST INDIES CHAMBERS OF COMMERCE.—Under the presidency of Sir Edward Davson, a meeting of the Associated Chambers of Commerce of the West Indies was recently held in Barbados. The existing passenger service came in for severe criticism, and it was agreed that prompt action was necessary, *i.e.*, that tenders should be invited for a direct mail and passenger service between the United Kingdom, the Lesser Antilles and British Guiana. Following upon the recommendations of the Colonial Office Shipping Committee, the meeting agreed that nothing short of a fortnightly service of steamers capable of carrying both freight and not less than 120 first-class passengers could be looked upon as adequate. The existing cable service between Great Britain and the West Indies also received much adverse criticism. With the exception of Jamaica, these Colonies have the most imperfect telegraphic communication with the home country of any British Possession throughout the world. This is evidenced by the fact that messages from British Guiana and Trinidad rarely take less than 10 days in reaching London, and frequently take as long as three weeks. Further, when they do arrive they are so mutilated as to be frequently indecipherable. The conference proposed as a remedy that an all-red cable route should be provided, and agreed that the law officers of the Crown should be asked as to whether the present broken state of the cables had not provided sufficient cause for a termination of the existing agreement between the Imperial Government and the West India and Panama Telegraph Company. The conference also dealt with other subjects of importance to the West Indian Colonies.